N° 540 - 2023

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Aides publiques et performances des entreprises nées mondiales

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Who Climbs Up the Income Ladder? An Analysis of Intergenerational Income Mobility in France

Michaël Sicsic*

Abstract – We study the intergenerational income mobility of individuals by directly comparing, for the first time in France, the rank of young adults between the ages of 27 and 30 on the income ladder with that of their parents, based on administrative data from the *Échantillon démographique permanent* (EDP, INSEE's demographic panel sample). The rank-rank correlation is 0.25 at age 29. Twelve per cent of the young people born to the poorest 20% of parents climb up the income ladder to the top 20%: this upward mobility rate is higher in France than in the United States and Italy, but lower than in the Nordic countries. Upward mobility is stronger the higher the parents' capital incomes and diploma, when parents are immigrants, are geographically mobile, or were living in Île-de-France when their offspring reached the age of majority. Conversely, being female, having lived in a single-parent family or in the Hauts-de-France region, or having parents who are manual workers has a negative impact on upward mobility.

JEL: J62, J61, D31, H0, R1
Keywords: intergenerational mobility, income, inequality, geographical variations

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Reducing the perpetuation of inequalities from one generation to the next has become a key objective for public policy and an economic policy consensus. Intergenerational mobility allows for more inclusive growth, where everyone has the same opportunity to thrive (OCDE, 2018), and can stimulate innovation (Aghion *et al.*, 2019). Conversely, positions that remain fixed from one generation to the next bring about losses in efficiency in the same way as under-investment in human capital (Becker & Tomes, 1979[1]). Poor mobility at the bottom end of the income distribution also leads to the loss of numerous potential talent and entrepreneurs (Bell *et al.*, 2019). Reducing the perpetuation of inequalities from one generation to the next will make it possible to move in the direction of equal opportunities (Roemer & Trannoy, 2016). However, although there is consensus with regard to the objective of encouraging mobility from one generation to the next, the diagnoses performed with regard to the intergenerational income mobility of individuals in France are at odds with one another (Dherbécourt, 2020). While the scale of intergenerational mobility is well documented when it comes to social position or occupation, this is not true when it comes to income since, until recently, there were no databases that would allow a person's income to be directly linked to that of their parents.

In this article, we study intergenerational income mobility by linking young adults' income to that of their parents a decade earlier for the first time in France, based on a very large sample of parent-child pairings. In order to do so, we use a rich administrative dataset panel, the *Échantillon démographique permanent* (INSEE's demographic panel sample – EDP), and in particular its fiscal and social section from 2010 to 2019. These data allow us to compare the individual income from employment of young adults aged 29 in 2019 with that of their parents in 2010, provided the parents and young people were living in the same tax household. As the income of the young people and their parents is not measured at the same age, it is the relative position of the parents in 2010 (within the distribution of parents' incomes) that is compared to that of young people in 2019 (within the distribution of young people's incomes). The rank-rank correlation between these positions provides a measure of the income mobility as shown by Chetty *et al.* (2014). The rank-based approach is far more robust than the conventional comparison of income logarithms, as was demonstrated by recent studies looking at mobility (see in particular Chetty *et al.*, 2014 and Nybom & Stuhler, 2017). The limitations in the data that led to the children's incomes being measured at the age of 29 causes the correlation to be underestimated when compared with an ideal situation in which the children's income could be measured at the same age as their parents, particularly as some remain in education for many years. Nevertheless, our findings are only slightly affected by life cycle bias given that almost all young people have entered the labour market by the age of 29 (only 0.8% are still in initial education according to Bernard, 2021). Finally, 29 years is very close to the age used by Chetty *et al.* (2011) (27 years) and Chetty *et al.* (2014) (30 years) for similar studies.

We then analyse upward and downward mobility by quintile according to socio-demographic characteristics and geographical locations through the use of Poisson regressions. As the EDP also includes tax data, we study intergenerational mobility from the perspective of capital income, which, to the best of our knowledge, has never been done before. In theory, wealth plays an ambiguous role in intergenerational mobility: on the one hand, significant parental wealth can reduce children's motivation for long studies or to get a job; on the other hand, significant wealth provides access to expensive training and also often goes hand-in-hand with greater social capital. We also look into the intergenerational income mobility of children of immigrants, which has never been studied before in France. Being descendants of immigrants can also have an uncertain impact on mobility: on the one hand, children of immigrants can suffer from discrimination and are more likely to live in poor areas, which can reduce their upward mobility. On the other hand, the fact that immigrants are more likely to live in large urban centres with more employment opportunities coupled with education-related factors can produce the opposite effect. In order to produce robust estimates based on all of the above characteristics, we are extending the scope of our study to young people aged between 27 and 30, resulting in a sample of around 60,000 parent-child pairings.

We estimate the rank-rank correlation, which measures the intergenerational persistence of income, at 0.25 at the individual-level. This rank-rank correlation increases slightly when we take account of the family's standard of living rather than individual income, or the income of the parent with the highest income rather than

1. In their founding model, these economists include parents' investment in their children's human capital in the analysis of inequalities.

the average income of both parents. However, this correlation masks a high degree of heterogeneity: the position of children varies greatly when parents' income is fixed.

The study of mobility between income quintiles completes our review of intergenerational mobility in France. It first of all confirms that inequalities are passed from one generation to the next: young people from families in the top 20% of the income distribution are three times more likely to be ranked among the wealthiest 20% than those from the poorest 20% of families. However, this analysis also reveals a degree of mobility: 73% of young adults belong to a different income quintile than their parents, and of those young adults aged 29 years born to parents in the bottom 20%, 12% reach the top 20% of their generation as adults. This upward mobility is higher than that observed in the United States and Italy, but falls below that seen in Canada and Sweden.

Based on Poisson regressions, we demonstrate that upward mobility is even greater when parents have high capital incomes, when the parent with the highest income is at least a high-school graduate (baccalaureate diploma) when they are immigrants, when the family was geographically mobile during the individual's childhood and when the young person was living in Île-de-France upon reaching the age of majority. Conversely, the fact of being female, having lived in a single-parent family or in the Hauts-de-France region, or having parents who are manual worker has a negative impact on upward mobility.

Literature Review and Contributions

Our work build on an extensive literature on intergenerational mobility. Although intergenerational social mobility in terms of social categories has formed the subject of numerous studies in France (see, for example, Vallet, 2014), thanks to the survey *Formation et qualification professionnelle* (Training and vocational skills, FQP), mobility in terms of income is yet to be addressed in depth due to a lack of data. However, two types of studies have previously been conducted in France. The first links income to the occupation of the parents, the so-called 'mixed' method implemented by Lefranc *et al.* (2004), Dherbécourt (2018) and Dherbécourt & Kenedi (2020). The other imputes parents' income based on other information: Lefranc & Trannoy (2005) in a seminal article on French data, followed by Lefranc (2018), OCDE (2018) and Alesina *et al.* (2018), impute the average income of fathers using a two-sample two-stage least squares estimation procedure (popularised by Björklund & Jäntti, 1997) based on the FQP and SILC and estimate the intergenerational elasticity (IGE) of income. Kenedi & Sirugue (2021) also use this method to calculate different mobility indicators at the national and departmental level, this time using the EDP.[2] Compared to these studies, our main contribution is to provide a direct comparison of income observed with the income observed for the parents, which removes the reliance on imputation assumptions.[3] Our study also makes it possible to cover all of the sectors of individuals and their parents, including the public sector and the self-employed.

Our study is close to recent studies performed using non-French data. It largely follows the study by Chetty *et al.* (2014). That study is, in turn, based on those by Solon (1999) and Black & Devereux (2011), who focus on intergenerational income mobility in the United States, using administrative data with parents' incomes observed. Corak & Heisz (1999), Schnitzlein (2016), Boserup *et al.* (2014), Nybom & Stuhler (2017), Muray *et al.* (2018), Helsø (2021) and Acciari *et al.* (2022) implement similar methodologies using Canadian, German, Danish, Swedish, Australian and Italian data. One of the innovative contributions made by our study is our description of intergenerational income mobility for a new country, France. Our findings show that positional mobility appears to be higher compared with the United States and Italy, but similar to that observed in Australia at the same or a similar age. However, it appears to be lower than in Switzerland, Sweden, Denmark and Canada. Our data also allow us to describe intergenerational mobility according to a number of socio-demographic and geographical characteristics. In particular, to the best of our knowledge, this is the first time that mobility has been described based on parents' capital income, which allows us to study the way in which capital ownership influences mobility.

The remainder of the paper is structured as follows. The first section describes the data used,

*2. In particular tax data for the children and annual declarations of social data (*Déclaration annuelle de données sociales, *DADS) for the parents. Self-employed persons and civil servants are therefore not covered (as they are not included in the DADS data). Our estimates of rank-rank correlations at the individual level, obtained from a sample of children of comparable ages, are very close to theirs, and are obviously lower when compared with those made by the authors with regard to household income (due to the homogamy effect).*

3. The imputation method tends to bias intergenerational elasticity by 0.1 point or more (Björklund & Jäntti, 1997; Acciari et al.*, 2022; Kenedi & Sirugue, 2021).*

the construction of the dataset, the methodology and provides descriptive statistics. The second section sets out the results at the national level and proposes robustness checks. Finally, the third section describes mobility according to the socio-demographic and geographical characteristics of the population, expanded to cover those aged from 27 to 30 years.

1. Data, Coverage and Descriptive Statistics

1.1. Data

The *Échantillon démographique permanent* (EDP) is a panel of individuals established and managed by INSEE since 1968. Up until 2007, it gathered administrative information on all persons born on the 2nd, 3rd, 4th or 5th of October and, since 2008, it has been gathering information regarding persons born on the 2nd, 3rd, 4th or 5th of January and one of the first four days of the final three quarters of the year (referred to as the 'sixteen EDP days'). Since 2008, it has been representative of just over 4% of the French population each year (around 1% previously). Although the EDP historically only gathered data from the civil register and the population census, it now also collects data from the Annual Social Data Declarations (*Déclaration annuelle de données sociales* – DADS), from the electoral register and, since 2015, fiscal and social data (FIDÉLI and FILOSOFI) (Robert-Bobée & Gualbert, 2021). The fiscal data provided by the 2020 edition of the EDP cover all incomes during the years from 2010 to 2019 (2011 to 2020 fiscal years):[4] They provide annual data on all 'EDP individuals'.

The EDP provides a wealth of tax-related information that makes it possible to track the detailed personal income of the 'EDP individual', as well as all other individuals included in the tax return of that individual. The EDP also includes comprehensive census data from 1968 to 1999 and the annual census surveys conducted since 2004. Finally, the EDP includes annual information regarding the employment of the 'EDP individual' alone, which is taken from the DADS; however, this only includes employees and is only available up to 2018.

The different steps in which the data are processed (including re-weightings in particular) are presented in Box 1.

1.2. Coverage

We are interested in people born between 1989 and 1992, identified within the fiscal data as living in the same fiscal household as their parents (or one of their parents) in 2010, 2011 or 2012, who have positive or zero income in 2019 (when they are between 27 and 30 years old) and whose parents have positive or zero income in 2010. We restrict the coverage to metropolitan France. The effects of the various restrictions are set out in Online Appendix S2 (link to the Online Appendix at the end of the article). Persons born after 1992 are excluded, as some of those belonging to these generations are still in initial education (the oldest among them are 26 years old in 2019), and those born before 1989 are also excluded, as too few of them are still living in their parents' fiscal household in 2010, 2011 or 2012 (when they are 22 years of age or older) and are too heavily impacted by the selection effect (see Section 2.2 and the Online Appendix). Analyses of the rank-rank correlation and intergenerational mobility matrices (Box 2) are limited to the generation born in 1990, who were 29 years of age in 2019, in order to minimise life cycle bias[5] and selection bias.[6]

Although we only use persons aged 29 (or between 27 and 30 years for the final section), some are potentially still students: their observed standard of living is very unlikely to be the same as the standard of living they will have once they enter the labour market. This issue does not seem likely to introduce a bias into our analysis, since only 0.8% of individual over the age of 29 are still in initial education (Bernard, 2021). We also use the 2019 *Enquête annuelle de recensement* (Annual Census Survey) to identify and remove students identified therein from our sample. However, this correction does not allow us to take account of the existence of individuals who are unemployed.

1.3. Definition of Incomes Variables

We turn now to describe the main income variables used in this section. The other income variables and the socio-demographic variables are described in Online Appendix S3.

The parents' individual incomes are derived from the information declared to the tax authorities (pre-filled for the majority of the population and therefore very reliable) through the use of the FIDÉLI database. The individual income of

4. In the following, we will only mention income years and not fiscal years.
5. This bias corresponds to the fact that children are observed at a younger age than their parents, and at a time when their labour market situation is not fully stabilised, which can lead to the overestimation of intergenerational mobility indicators. Chetty et al. *(2014) demonstrate that this bias becomes very small from the age of 29-30 years (see Section 2.2 for further details).*
6. Individuals aged 30 and over remained with their parents until relatively late (22 years), which could lead to a bias (see below).

Box 1 – **Treatments Applied to Build the Database**

To ensure that their income can be linked to that of their parents, we select persons from the EDP born between 1989 and 1992 who were living in the same fiscal household as their parents in 2010 in the income tax returns. This means that we get the information of their parents' income for 2010. We also have the income of these people in 2019, when they were between 27 and 30 years old, which is the most recent year for which tax data is available. This allows us to compare the parents' incomes in 2010 with that of their child in 2019.

However, tax information concerning the parents of 'EDP individuals' is not directly available within the EDP: the only data available for 2010 is the income of the declarant and any partner provided in the tax returns in which the EDP individual appears. We then compare the parents' individual information, taken from the general tax source table in the EDP, with that of the declarants and their partners taken from the detailed table of income from that same source in order to determine whether the declarant and their partner are the mother or father of the EDP individual. In the tax returns in which the EDP individual is declared, the 'declarant' and the 'declarant's partner' are the potential parents of these individuals. In some cases, these may be step-parents in the event that the parents of the EDP individual have previously separated and one of the parents has entered a new partnership (see Abbas & Sicsic, 2022 for further details). This approach remains relevant: on the one hand, blended families are still few in number (in 2018, 11% of 15–17-year-olds were living with one parent and one step-parent) and, on the other hand, we are more interested in measuring the perpetuation of inequalities linked to standard of living and the economic situation experienced during childhood than in identifying the precise situation with regard to biological parents.

As the information provided by tax data is of poorer quality for minors than for adults, the number of people born between 1989 and 1992 found in the tax data increases after 2010 as these people become adults. In order to tackle this issue and to increase the size of our cohorts, we supplement the sample of persons found in the tax data for the year 2010 with persons who are only present in 2011 or 2012 and not in 2010. We consider the family situation and income of the parents of those present in 2011 or 2012 to be the same as those for 2010 (correcting for income inflation), since they still appear as dependent children in their parents' tax returns. This approach allows us to largely, but not fully, reconstitute the various cohorts studied for the purposes of this article (Abbas & Sicsic, 2022). The data are also weighted in order to build a sample of children that is representative of the French population. As the weighting available in the fiscal data included in the EDP do not allow for a precise reconstitution of the French population by age and by gender, we correct it on the basis of tax data and by using INSEE's detailed records of the French population by age, gender and marital status using a two-step method (see Online Appendix S2). Alternative weightings are also applied as robustness checks.

We also add socio-demographic data available in the EDP to our database. However, this information (taken from the 1999 population census) only concerns EDP persons born on one of the four historical EDP days (and not on one of the sixteen EDP days, as has been the case since 2008). We therefore supplement the database using the annual census surveys conducted between 2008 and 2019. The total coverage rate of our sample by either the 1999 survey data or an annual census survey is more than 70% on average for each generation (compared with 25% if we rely solely on the information available in the EDP). Since this coverage rate differs from one generation to the next, reweighting was performed in the analyses using these variables. Details of all of these treatments are provided in Online Appendix S1.

Box 2 – **Intergenerational Income Mobility Indicators**

1. Rank-rank Correlation

An initial measure of intergenerational mobility involves a comparison of the rank of children with that of their parents within their respective income distributions. Let R_{ei} be the rank (in percentile) of *i* within the income distribution for their generation, and R_{pi} the rank (in percentile) of the parent of *i* within the income distribution for the parents of that generation. The rank of the young people can be regressed on the rank of their parents as follows:

$$R_{ei} = C + \beta R_{pi} + \varepsilon \qquad (1)$$

where C is a constant. The coefficient β is the correlation coefficient between R_{ei} and R_{pi}, since both child and parent ranks follow uniform distribution for which the standard errors are identical. We will therefore refer to this coefficient as the 'rank-rank correlation' or RRC and, in some cases, as the 'rank-rank slope' in reference to the slope of the regression. If the correlation is zero, the position of an adult within the employment income distribution isn't linked to that of their parents, and their relative income mobility is very high. Rank-rank correlation therefore provides a measure of the persistence of income between generations. We will sometimes use this term in the following to refer to this indicator.

The rank-rank correlation is linked to intergenerational income elasticity (IGE), which is often studied in the literature and estimated by regressing the logarithm of income on the logarithm of income for the parents. The IGE therefore corresponds to the correlation coefficient ρ_{ep} between the log of income and the log of parents' income multiplied by their standard error ratio. The rank-rank correlation β and the income log correlation ρ_{ep} are very conceptually close,[(a)] the difference between the rank-rank correlation and the IGE being the income standard error ratio: the IGE takes account of the degree of inequality (an increase in parents' income having a greater

➔

Box 2 – *(contd.)*

impact on their children's income where there is greater inequality between children than between their parents). This is especially important when comparing countries with very different levels of inequality, such as France and the United States.

The comparison of ranks is far more robust than the conventional comparison of income logarithms, as was demonstrated by recent studies of mobility (see in particular Chetty *et al.*, 2014, Nybom & Stuhler, 2017 and Acciari *et al.*, 2022). Indeed, the IGE is very sensitive: *(i)* to the treatment of zero or negative income (due to the use of logarithms); *(ii)* to attenuation and life cycle bias (date on which the children's income is observed), more so than to rank-rank correlation; *(iii)* to the way in which the parents' incomes are estimated (observed or imputed). In addition, the relationship between the income of individuals and their parents is highly non-linear, unlike when the rank-based approach is applied.

2. Intergenerational Quintile Transition Matrix and Upward Mobility

A second way of studying intergenerational mobility involves focusing more specifically on upward mobility. The indicator used is the probability that a person whose parents belong to the bottom 20% of the income distribution for parents will find themselves in the top 20% of the income distribution. This is referred to as 'upward mobility' or the 'B20/T20 ratio' (Bottom 20%/Top 20%). It is also possible to measure the probability that a person whose parents fall into the poorest 40% will themselves be among the wealthiest 40%. We will refer to this indicator as 'expanded upward mobility' (or the B40/T40 ratio). This indicator allows us to include more individuals in our econometric analyses (double the amount). These two indicators have the advantage of offering simple and clear graphical representations. It should be noted, however, that the findings must be interpreted with caution, as the intervals group together the same number of people, but do not cover the same range in terms of euros. The intervals at the extremes of the distribution are therefore broader than those in the middle, which implies greater mobility in the middle quintiles than at the top and bottom ends of the distribution.

(a) *According to the degree to which the child's income relies on that of their parents.*

the father (or the mother) is the sum of their employment income, unemployment benefits and pensions, as reported in the income tax return, i.e. net of contributions and the deductible CSG. The parents' income is defined either as the average of the individual incomes of the two parents (where the child is fiscally linked to both of their parents who are married to each other or in a civil partnership), or as the individual income of the single parent with whom they are linked. That income is then divided by the size of the household, which is achieved by dividing it by the number of adults in the household and, for a robustness check, by dividing it by an equivalence scale. These incomes are observed in 2010.

The individual employment income of the children is also derived from the FIDÉLI database, integrated into the EDP and calculated by adding together employment income and unemployment benefits. This income is observed in 2019.

Alternative measure of income. The parents' equivalised disposable income (also named standard of living),[7] taken from FILOSOFI, is used to give supplementary results, and is not used in the main analysis since this variable is not available for the children. Indeed, it is difficult to separate the standards of living of children from those of their parents, as they may live with their parents for a long time after reaching the age of majority. In this case, the standard of living of the parents and children is the same: in both cases, this is effectively the standard of living of the whole family, as it takes account of both the parents' and the children's income. According to Pouliquen (2018), 20% of young people aged between 25 and 29 spend all or part of the year living with their parents. Although this rate decreases with age, it still remains above 6% between the age of 30 and 35. However, in spite of these limitations, an analysis limited to children who moved house between 2010 and 2019 (probably from their parents' house, having thus a different standard of living to their parents) will be presented in robustness checks section.

The income scale. Young people belonging to the same generations are ranked within their birth cohort according to their income on a scale of 1 to 100: from the first percentile for the lowest 1% of incomes among the generation

7. The standard of living of the parents corresponds to the standard of living of the household to which the young person was attached in 2010. The standard of living is calculated as equivalised disposable income (i.e. income from employment and capital, less taxes and with the addition of social security benefits paid in cash). It also takes account of any child support payments made in the event of separation. The data is taken from the FILOSOFI database. Any income received by the young person is subtracted to calculate the parents' standard of living.

up to the hundredth percentile for the highest 1% of incomes among the generation. Likewise, parents are ranked (from 1 to 100) relative to other parents with children in the same birth cohort. This strategy makes it possible to correct for the fact that the parents' income is observed at a different – older – age than that of the young people (which is seen throughout the literature, Chetty *et al.*, 2014) and to take account of the different ages of the children.

1.4. Descriptive Statistics

If we combine the generations from 1989 to 1992, there are around 60,000 parent-child pairings in our sample, which represent 3.1 million young people after treatment and restrictions of coverage (see above). Each generation comprises between 10,000 and 18,000 parent-child parings (Table 1), with the number increasing in line with the birth year (due to the fact that these people had to be included in their parent's tax declaration in 2010, 2011 or 2012).

Around half of our sample is made up of daughters (Table 1). The average age of the parents is around 50 years and approximately 90% of the parents are aged between 40 and 60 years in 2010. In 2010, around half of the individuals in our sample were living in a dwelling with both of their parents, and possibly one sibling, and around one quarter were living in a dwelling with multiple siblings.

Figure I represents the average individual income of individuals aged between 27 and 30 in 2019 based on the income percentile rank to which they belong: the curve takes on a tilde shape with an almost straight line between the 20th and 80th percentile. At the lower end of the distribution, 6% of young people have zero or almost zero incomes, then incomes increase significantly to 12,000 euros at the 20th percentile. The median is almost 20,000 euros (it varies between 17,000 and 22,000 euros depending on the generation, see Table S2-2 in the Online Appendix S2), and the 80th percentile is 29,500 euros. There is then an exponential increase from the 80th percentile: the average income is almost 36,000 euros at the 90th percentile, 61,000 euros at the 99th percentile and 93,000 euros at the top percentile. The shape of the curve is largely the same if we plot the parents' average income for each percentile of the distribution of their incomes; however there are of course, fewer zero incomes and incomes are higher, particularly at the top end of the distribution (the 90th percentile is 41,000 euros and the 99th percentile is more than 160,000 euros). The difference between the threshold of the wealthiest 20% and that of the poorest 20% is 17,500 euros per year. That same inter-quintile gap is higher for the parents, amounting to almost 20,000 euros. It should be noted that the exclusion of individuals who declare their income alone at the age of 18 slightly inflates the figure for the income of young people within our sample when compared with their generation as a whole, and also leads to a slightly higher proportion of wealthy parents (more managers and higher-education qualifications) within the sample than within the general population (Abbas & Sicsic, 2022). However, correcting this by means of reweighting does not change the outcomes (see Section 2.2).

2. Findings at the National Level

2.1. Intergenerational Mobility Indicators

We start by commenting on the findings related to the rank-rank correlation (RRC), followed by those related to the transition matrices (cf. Box 2 for the concepts).

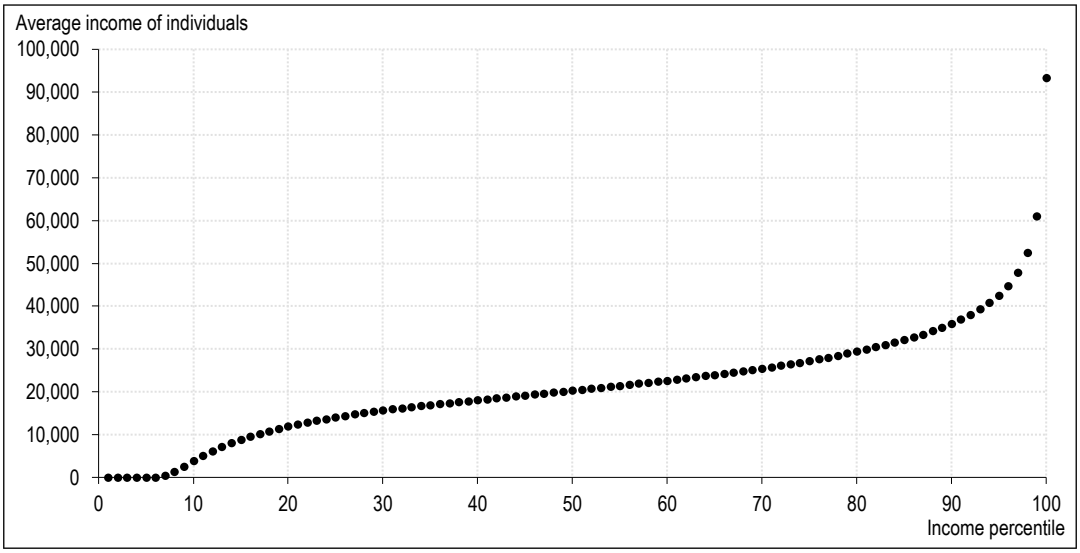
Figure II shows the rank-rank relationship: the average percentile at the age of 27–30 based on the percentile of parental income. The relationship is positive and, remarkably, almost linear

Table 1 – **Descriptive statistics**

Generation (age in 2019)	Population		Proportion of daughters (%)	Age of parents in 2010		Family composition in 2010 (%)		
	Not weighted	Weighted		Father	Mother	Couple with 1 or 2 children	Couple 3 or more children	Single-parent family
1989 (30 years old)	9,644	780,866	50	53	50	51	24	21
1990 (29 years old)	13,791	792,576	49	52	49	50	24	21
1991 (28 years old)	17,926	789,443	48	51	48	49	25	22
1992 (27 years old)	18,803	784,897	48	50	47	48	26	21
89-90-91-92 (27-30 years old)	60,164	3,147,782	49	51	49	49	25	21

Notes: The family composition is the composition of the individual's family in 2010. The proportion of complex households is not indicated (relatively small, around 5%).
Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

Figure I – **Average income of young adults based on their income percentile in 2019**



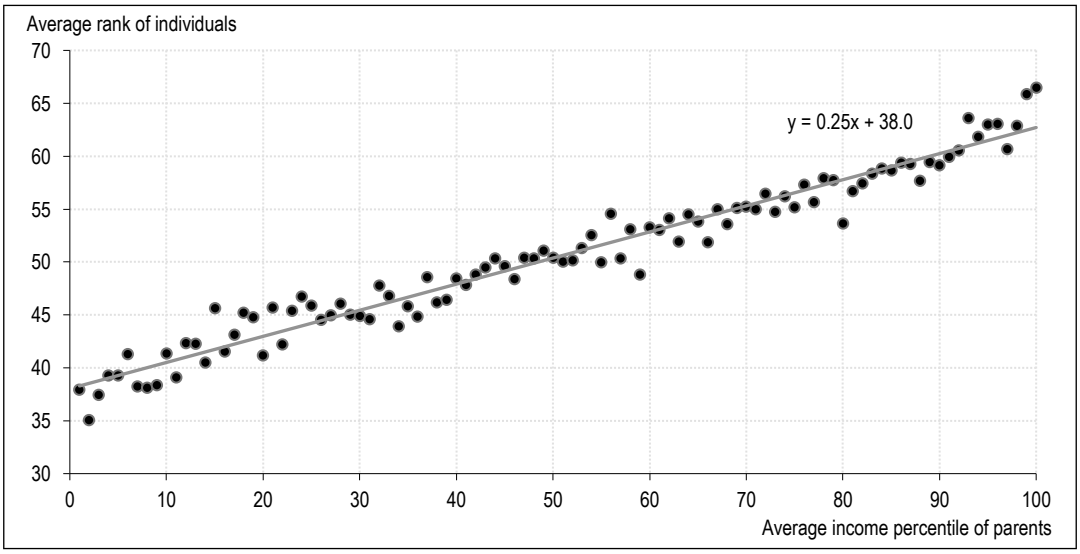
Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2019. Metropolitan France. Individuals born between 1989 and 1992, included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

(a little steeper, except at the beginning and the very end of the distribution). The correlation is slightly stronger when we take account of the parents' highest income rather than their average income,[8] is similar when the father's income is taken into consideration, but less so when the mother's income is used (see Figure S4-2 of Online Appendix S4).

The estimation of the equation using the ordinary least squares method (cf. Box 2) for young people aged 29 years gives a RRC of 0.25: in other words, a person whose parents are classed ten income percentile higher than those of another person are, on average, ranked 2.5 income percentile higher. For young people aged 30, and more generally for those aged between 27 and 30, the average correlation is also 0.25 (Figure II). This persistence of income from one generation to the next can be explained in part by the fact that the children of wealthy parents are more likely to pursue higher education, as was demonstrated recently by Bonneau & Grobon (2022) in France and

8. Figure S4-1 is the same as Figure II, but uses the parents' highest income rather than their average income (see Online Appendix S4).

Figure II – **Average rank of young adults based on the income percentile of their parents**



Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals born between 1989 and 1992, included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

Chetty *et al.* (2020) in the United States.[9] The correlation of 0.25 estimated based on our data is very close to that obtained at the individual income level by Kenedi & Sirugue (2021) by imputing parents' income for France at the age of 29 (0.244). The comparison with other countries is not clear, as the RRC differs depending on the type of income taken into account and the age at which it is estimated. In order to carry out robust cross country comparisons, we compare studies with the same concept of income to ours (individual income) and compare mobility at the same age: around 5%[10] must therefore be added to our estimates for persons aged 29 in order to estimate the value for persons aged 35 (which is generally the reference age used in the literature). The RRC of individual income in France would then be higher (and mobility therefore lower) than that obtained in Switzerland (0.14 according to Chuard-Keller & Grassi, 2021), Sweden (0.2 according to Heidrich, 2017 and even below 0.2 at the age of 28-29 according to Nybom & Stuhler, 2017), Denmark (0.20 according to Boserup *et al.*, 2014 and 0.22 according to Helsø, 2021) and Canada (0.17 according to Corak & Heisz, 1999).[11] Conversely, according to the findings made by Chetty *et al.* (2014), who obtain a coefficient of 0.29 for individual income[12] and 0.32 for household income at the age of 29, it appears that the persistence of individual income is lower (and mobility therefore higher) in France than in the United States. The persistence of income also appears to be lower than in Italy, where Acciari *et al.* (2022) find a RRC of 0.30[13] across a sample of children aged 36. The RRC appears to be relatively close to that obtained at the individual level in Australia by Murray *et al.* (2018) of 0.26 when we increase our estimate by 5%.

The regression intercept (which is the same as the intercept shown in Figure III) is 38.0. The average rank of young people whose parents are at the 25th percentile of the distribution, also called "absolute upward mobility" in the literature, is the 44th percentile (38+0.25*25). It should also be noted that the R^2 of the regression, which measures the proportion of the variability in the ranks of the young people that is explained by the rank of their parents, is relatively low at 6%.

The correlation between their income and that of their parents is largely unchanged when the parents are classified based on definitions of income other than average individual income. The RRC is therefore slightly higher (0.26%) when parents are classified according to their equivalised initial income or according to their equivalised disposable income (Table 2). It is a little higher still if the highest income of the parents is used rather than their average income, and a little lower if their average declared income (for tax purposes) is used. The RRC is slightly higher when the father's income (0.26) is used, but significantly lower when the mother's income (0.16) is used. The correlation is also systematically slightly higher for daughters (see below), while the correlation between the rank of mothers and the rank of sons is negative, whereas it is positive (but weak) and significant for daughters.

The previous analysis was carried out by expressing the average ranks of the young adults based on the rank of their parents. However, these ranks vary greatly with respect to a given parent's rank. In addition to the average, Figure III shows the three quartiles of the children's income percentile for each of the parents' income percentile. The slope of the median is steeper than the slope of the mean, particularly at the top end of the distribution. This difference is linked to the fact that there are extreme upward and downward mobility (respectively) that make the mean rank of sons and daughters within the lowest (or highest) percentile higher (or lower) than the median. This finding was previously observed by Acciari *et al.* (2022) in Italy. By regressing the median of the percentile of the children's ranks on the parents' ranks, a slope of 0.39 is obtained (see Table S4-4 in the Online Appendix), i.e. significantly higher than when regressing the mean of the ranks.

A study of the rank quartiles reveals a high degree of heterogeneity among the ranks of the children when the parents' ranks remain fixed. The interquartile difference in the conditional distribution of the children's ranks, at a given parental income, is 46 percentile (Figure III), a Figure very similar to that found by Acciari *et al.*, 2022, while the interdecile difference is more

9. The fact that higher education is more valuable in the United States (ie. higher wage premium with higher education) may explain the persistence of higher incomes in the United States.

10. In France, Kenedi & Sirugue (2021) find a difference of 4% between the rank-rank correlation at 29 years old and at 35 years old for individual income (and 12% for household income). In the United States, Chetty et al. *(2014) observe a difference of around 5% in the age at which the correlation stabilises (or almost zero when longer data are used to compare with income at 40 years of age).*

11. The correlations observed in these countries are estimated on the basis of a concept of individual income that is similar to ours. However, these are measured at ages over 30 years and are therefore likely to be lower under the age of 30.

12. Unlike findings in terms of family income, the authors do not present these results by age, but the rank-rank correlation would still be lower in France, even if the life-cycle correction is applied.

13. In their most reliable estimate, taking account of all sources of bias. The estimate without correction is 0.22. The authors use a definition of income that is very similar to our own for individual income.

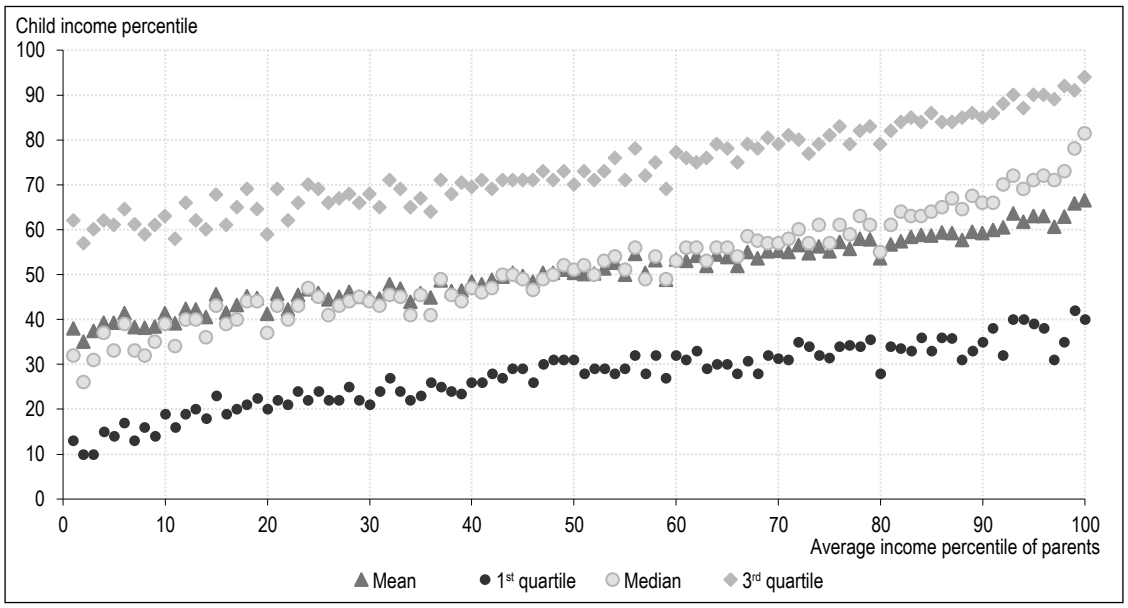
Table 2 – **Rank-rank regression according to the parental income**

	Dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
Average income of parents	0.249*** (0.008)					
Average equivalised income		0.256*** (0.008)				
Average equivalised disposable income			0.255*** (0.008)			
Maximum income of parents				0.264*** (0.008)		
Father's income					0.257*** (0.008)	
Mother's income						0.160*** (0.009)
Constant	37.918*** (0.481)	37.546*** (0.480)	37.629*** (0.480)	37.714*** (0.479)	38.916*** (0.501)	45.484*** (0.553)
Observations	13,707	13,707	13,707	13,707	12,761	10,825
R^2	0.062	0.066	0.065	0.070	0.057	0.016
Adjusted R^2	0.062	0.066	0.065	0.070	0.057	0.016
Residual Std. Error	211.753 (df= 13705)	211.332 (df= 13705)	211.428 (df= 13705)	210.899 (df= 13705)	215.094 (df= 13705)	218.646 (df= 13705)
F Statistic	906.760*** (df= 13705)	964.999*** (df= 13705)	951.751*** (df= 13705)	1025.328*** (df= 13705)	766.499*** (df= 1; 12759)	174.977*** (df = 1; 10823)

Notes: Estimates of the coefficient β of the equation (1). The standard errors are shown in brackets.
Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals aged 29 (born in 1990), included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

than 80 percentile at the top end of the distribution. Even at the lower end of the parents' income distribution, a quarter of individuals exceed the 60th percentile (and 10% exceed the 80th percentile), while at the very top, a quarter of children have incomes below the 30th percentile (and 10% have incomes below the 10th percentile). This variability in the income positions of certain parents has already been observed in accordance with given social categories of parents by Lefranc *et al.* (2004). We therefore observe numerous cases of upward and downward mobility, indicating that parents' income is not the only factor determining children's income.

Figure III – **Percentile in which individuals are ranked according to their parents' rank**



Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals born between 1989 and 1992, included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

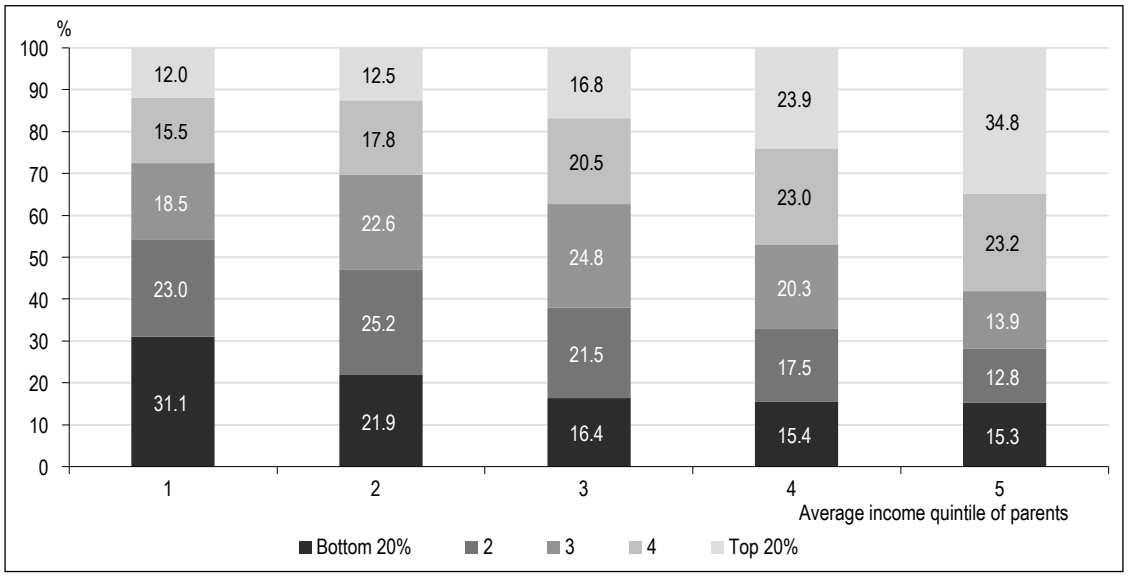
Turning now to intergenerational transition matrix across quintiles, we observe that 73% of persons aged 29 belong to a different income quintile than their parents. Thirty-one per cent of those whose parents are in the bottom of their distribution remain in the bottom 20% (a phenomenon often referred to as the 'sticky floor' phenomenon), while, at the opposite end of the scale, 12% climb up the income ladder to the top 20% (Figure IV). This latter rate of upward mobility is a little less marked among those aged 30, at 11%. This is very close to the figures obtained by Alesina *et al.* (2018) and Kenedi & Sirugue (2021) using French data, who assessed it at 11% and 10%, respectively, bearing in mind the differences in method and scope (these studies impute the parents' income, involve persons over 30 years of age and use different definitions of income). The rate of upward mobility is significantly higher than in the United States (7.5% according Chetty *et al.*, 2014, and 7.8% according to Alesina *et al.*, 2018), Italy (8.6% according to Acciari *et al.*, 2022, and 10.4% according to Alesina *et al.*, 2018) and Germany,[14] but lower than in Canada (13.4% according to Corak & Heisz, 1999) and Sweden (15.7% according to Heidrich, 2017).[15] Conversely, 35% of persons aged 29 born to parents in the top 20% remain at the top 20% (referred to as the 'sticky ceiling' phenomenon).[16] Therefore, members of the wealthiest 20% of families are three times more likely to themselves be among the wealthiest 20% (of their generation) than members of the poorest 20% of families. Fifteen per cent of children exhibit downward mobility towards the poorest 20%. This percentage is reduced if we use the income of the household to which the person belongs rather than their individual income, partly due to the temporary unemployment of one of the two partners upon the birth of a child within the couple.[17]

Finally, if we broaden the definition of upward mobility to include persons whose parents fall within the poorest 25% (or 40%) who subsequently find themselves in the wealthiest 25% (or 40%), the mobility rate is 16.5% (or 29%). Conversely, mobility between the poorest 10% and the wealthiest 10% is consistently lower, but remains significant: 4% of people whose parents are among the poorest 10% are themselves among the wealthiest 10%.

These figures are robust to the way in which the parents' income is measured, regardless of whether it is equivalised initial income, equivalised disposable income, the highest of the two

14. According to Schnitzlein (2016), the rate of upward mobility between the quartiles at the extremes of the distribution is 15% in Germany. According to our findings, it is 17% in France. The OCDE (2018) also calculates a much lower rate of upward mobility in Germany than in France.
15. The percentage of upward mobility appears to be much closer in Denmark (11.7 % according to Boserup et al.*, 2013) and Switzerland (Chuard-Keller & Grassi, 2021); however, these findings relate to an older age, so upward mobility is expected to be higher in these countries. We compare our estimation only with countries whose estimates are made at the individual level.*
16. That figure would have been 20% had their position on the income scale been by chance (perfect equality of opportunity).
17. The fact the downward mobility is higher among women is in line with this explanation. For example, Kenedi & Sirugue (2021) observe much lower downward mobility by using a definition of income at household level rather than at individual level.

Figure IV – **Quintile transition matrix in 2019 according to parents' income quintiles**



Reading note: 31.1% of children whose parents were in the bottom 20% (column 1) are themselves in the bottom 20% of the income distribution in their age category in 2019, and 12.0% are in the top 20%
Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals aged 29 (born in 1990), included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

parents' incomes or the average income that is taken into consideration (Table 3). However, upward mobility is slightly lower (11%) when the maximum income of parents and/or the standards of living of the parents is taken into account for children aged 29 years.

Table 3 – **Transition between income quintiles according to the definition of parental income used**

	Sticky floor (B20/B20)	Upward mobility (B20/T20)	Sticky ceiling (T20/T20)	Downward mobility (T20/B20)
Average income of parents (%)	31	12	35	15
Equivalised income (%)	31	12	35	15
Standard of living (%)	30	11	35	15
Maximum income of parents (%)	31	11	36	15

Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals aged 29 (born in 1990), included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

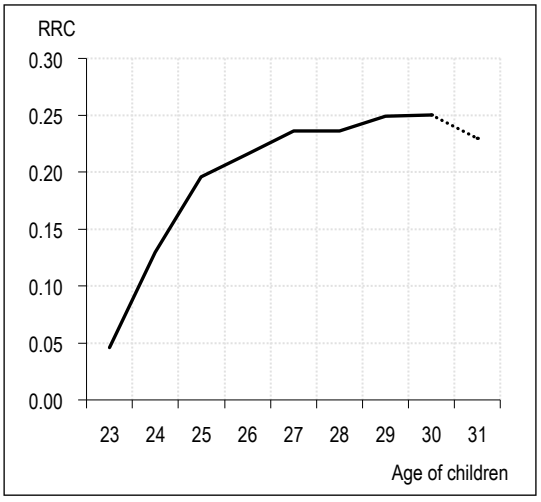
2.2. Robustness Checks

Lifecycle bias. This potential bias is linked to the fact that we are focusing on people who are still young (27 to 30 years of age) and therefore not necessarily in a fully stabilised position on the labour market (and therefore do not yet have a fully stabilised income). In order to assess the scale of this bias, in this section, we comment on the relationship between the rank-rank correlation and the age at which it is measured (Figure V). The RRC increases sharply between the ages of 23 and 25 (it is almost zero before this age); the increase slows between the ages of 25 and 27, is very slight from the age of 27 and stabilises at the age of 29. This backs up our decision to only present our findings for persons aged between 27 and 30 and to focus our analysis on those aged 29. It should be noted that the findings concerning persons aged 31 are affected by selection effects[18] and must be interpreted with caution (probable under-evaluation of the correlation). Different studies reveal that there may be a gap between the RRC at 29 to 30 years and that at 35 years, which brings an order of magnitude of life cycle bias: Kenedi & Sirugue (2021) calculate a difference of 4% (or 10%) between the RRC at 29 and at 35 (or 40) with regard to individual income in France, and Chetty *et al.* (2014) observe a very small gap (which may even be non-existent depending on the data used) between those aged 29 and those aged between 35 and 40. It should finally be noted that, according to a recent study (Loisel & Sicsic, 2023[19]) mobility throughout a person's life appears to be very low in France, which is indicative of low life cycle bias.

Finally, Table S4-2 in the Online Appendix shows the various statistics from the transition matrices for different ages. The findings concerning the 'sticky floor', upward mobility and the 'sticky ceiling', are very close whether they are measured at 27, 28, 29 or 30 years of age. Between 30 and 32% of persons born to parents in the bottom 20% remain in the bottom 20%, while 11–12% find themselves in the top 20%. Kenedi & Sirugue (2021) also find that upward mobility remains at the same level from the age of 27. These figures remain largely unchanged when standard of living is taken into consideration rather than the average income of parents (see Table S4-3 in the Online Appendix).

The findings of Section 3 below, which concern children aged between 27 and 30, primarily use upward mobility (see Box 2), the indicator that is the least sensitive to life cycle bias.

Figure V – **Rank-rank correlation according to the age at which it is measured**



Sources and coverage: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals aged between 23 and 31 in 2019, included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019.

18. This is linked to the fact that we only observe those who were still living in the same household as one or both of their parents in 2010, when they would have been 23 years old.

19. According to the authors, the rank-rank correlation is around 0.9 over 10 years, and the upward mobility 1.5%, (for individuals aged between 25 and 42, and 2%, for individuals aged 29).

Age of parents. Although we consider children of the same age, their parents are of different ages. We thus assess the sensitivity of our baseline estimates depending on the age at which parent incomes are measured. We show that, by controlling for the parents' age in the regression (1), the results are very similar. We also test restrictions on parents' ages. According to our data, less than 2% of mothers and 7% of fathers are over the age of 60. If we limit our sample to persons whose parents are between the ages of 40 and 60, we observe a very slight increase in the rank-rank correlation (0.254 compared with 0.249, see Table S4-4 in the Online Appendix), which is consistent with the fact that the correlation between the age of the parents and their position on the income scale is not significant.

Children's income. In this analysis, child income is defined at the individual level rather than household level with equivalised disposable income, as a significant proportion of 29-year-olds are still living with their parents and, by definition, their equivalised disposable income at the age of 29 is the same as that of their parents. However, the analysis can be limited to those who are no longer living in the same dwelling as they were in 2010 (i.e. their parents' home),[20] which excludes around 20% of individuals. Among this restricted population, the rank-rank correlation is 0.26 if the individual income of the children and their parents is used (see Table S4-4 of the Online Appendix), and 0.29 if the standard of living of parents and children is used (and remains below the figure obtained for the United States by Chetty *et al.* (2014) using this variable at age 29, which is 0.32–0.33). The fact that the correlation is higher for equivalised disposable income than for income is linked to social homogamy at the time of becoming a couple.

Weighting. The regressions are weighted (see above), but not weighting them makes little difference to the results (see Table S4-4 in the Online Appendix). We also tested different weight sets, allowing us to better correct for the selection bias and to align income with that of the general population (see Online Appendix S2). The rank-rank correlation varies from 0.23 to 0.26 depending on the weighting applied, while upward mobility between the bottom and the top 20% remains stable at 12% (with the exception of one scenario at 13%, see Table S2-3 of the Online Appendix). The weighting that we have used in our main findings gives central results and has the advantage of causing less distortion to the starting weights available in the EDP.

3. Mobility According to Socio-demographic and Geographical Characteristics

Tables S4-5 to S4-7 and Figures S4-4 and S4-5 of Online Appendix S4 break down the aforementioned mobility indicators according to the various characteristics of the individual (gender, year of birth), household (family configuration, capital income, occupancy status of the dwelling) or the parents[21] in 2010 (qualifications, occupations, migrant status) or geographical characteristics (region, department or size of the urban unit). To further investigate this, we use a modified Poisson regression with robust variance error (according to the procedure applied by Zou, 2004) that explains the B20/T20 upward mobility (and the expanded B40/T40 upward mobility) using these variables. Since the B40/T40 upward mobility involve twice as many people as the B20/T20 upward mobility, it results in more accurate estimators.

3.1. Analysis of Upward Mobility

Table 4 shows the relative risks (when compared with a baseline), referred to here as upward mobility relative chance[22] obtained by regression and the associated confidence intervals. Women are 1.5 times less likely to achieve the expanded upward mobility than men (column 1) and 1.8 times less likely to achieve B20/T20 mobility (column 3).[23] This is a significant difference and is consistent with the existence of a large gender gap when it comes to income. The probability of upward mobility is lowest for single-parent families and complex households (and, to a lesser extent, large families) than for couples with one or two children. This can be explained by the specific difficulties faced by these families. Conversely, the fact that parents have high capital income favours mobility. Therefore, the positive effects of capital (the ability to access expensive training or significant social capital) outweigh any theoretical negative impacts (lower incentives to undertake long-term studies or to find a job). These impacts are a

20. However, this approach does not allow for the exclusion of those who moved house with their parents between 2010 and 2019.

21. Reference person of the family defined as the parent with the highest income.

22. This is easier to interpret than the odds ratios resulting from logistic regressions, which may be interpreted incorrectly. Indeed, the odds in the odds ratio already correspond to a relative chance measured by a probability ratio (r/(1 – r), where r is the frequency of the event). This gives different results than a relative chance when r is not particularly small, as is the case in our study (see Figure S4-9 in Online Appendix S4).

23. The univariate analysis indicates that men have a 15% (or 34%) probability of achieving B20/T20 (or B40/T10) upward mobility, compared with 8% (or 24%) for women (see Table S4-7 in Online Appendix S4). This is also consistent with the fact that the rank-rank correlation is higher for daughters than for sons (by around 0.03 points).

little lower than those revealed by a descriptive univariate analysis,[24] but remain very significant. Likewise, children whose parents are homeowners have a higher probability of achieving upward mobility and a lower probability of remaining at the bottom end of the distribution and experiencing downward mobility.

Persons for whom the highest earning parent is an immigrant are far more likely to climb up the income ladder than those whose highest earning parent is not an immigrant.[25] This is consistent with the findings obtained by Abramitzky *et al.* (2021) for the United States, which reveal stronger upward mobility among immigrants for more than a century. This is partly linked to the fact that immigrants are more likely to live in large urban centres with more employment opportunities; however, we demonstrate that this finding remains valid even when controlling for location. Abramitzky *et al.* (2021) emphasise that this is primarily linked to the fact that immigrant fathers are paid less well than non-immigrants with the same skills (with this being especially true for those who immigrated later than in early childhood, due to a poorer grasp of the language, which prevents them from finding a job that matches their qualifications). In addition, among the descendants of immigrants, upward mobility is most prevalent among those whose parents come from Asia (30%), followed by those from America and Europe (19%). The figure is lowest for those from sub-Saharan Africa (13%), though this is still higher than that for children whose parents are not immigrants (10%). However, it should be noted that this more frequent upward mobility for immigrants goes hand-in-hand with an increased risk of remaining at the bottom end of the distribution or experiencing downward mobility (see below).

Persons whose highest-earning parent (often the father) is educated to at least baccalaureate level are significantly more likely (around 1.3 times) to achieve upward mobility, all else being equal.

The differences in mobility according to social origin (measured by occupation) are much smaller when estimated controlling for other characteristics: there is therefore no significant link between the fact of having a father in a management position rather than an intermediate profession and higher B40/T40 upward mobility. Conversely, upward mobility is weaker for the children of manual workers (0.8) than for the children of parents in intermediate professions.

Finally, persons whose family was geographically mobile during their childhood are also more likely to achieve upward mobility, and income persistence is lower for them.

The probability of upward mobility is significantly higher for those who grew up in Île-de-France compared with those who grew up in Auvergne-Rhône-Alpes. It is significantly lower in Hauts-de-France than in Auvergne-Rhône-Alpes. In order to determine whether differences in mobility from region to region are linked to differences in average income between those regions, we add the quintile of median income of the municipality or urban area in which the person was living in 2010 to the regression. By adding this variable, there was no significant difference between Île-de-France and Auvergne-Rhône-Alpes, but the probability of mobility remains lower in Hauts-de-France (see Figure S4-6 in the Online Appendix). The values of the coefficients for the other regions also remain similar to those obtained without controlling for the income of the area of residence in 2010. Therefore, the specific effect of the territories remains, even when we control for the level of income, except for the Île-de-France region, the positive results of which appear to be linked solely to its level of wealth.

Finally, we look directly at whether upward mobility depends on the characteristics of the territory of origin. We observe that, all else being equal, there is a higher probability of upward mobility in areas in which the rate of graduates and GDP per capita are the highest; however, there is no difference when we take account of the type of area that the territories exhibit (see Figure S4-7 of the Online Appendix).

It is also interesting to note that we have not identified any correlation between mobility and standard of living inequalities at the regional and departmental level (or even based on other zoning), which is different from the findings of Chetty *et al.* (2014) in the United States. A positive correlation appears between upward mobility and the median income of the territory (see Abbas & Sicsic, 2022 for more details). This could be linked to the fact that the wealthiest territories are the most attractive and offer more employment opportunities, thereby creating favourable conditions for upward mobility.

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24. 21% (or 40%) of individuals whose parents are among the top 10% of capital income achieve upward B20/T20 (or B40/T40) mobility, compared with 10% (or 26%) of those whose parents receive below-average capital income.

25. Descendants of immigrants also have a lower rank-rank correlation, which is even lower (0.13) for descendants of immigrants who hold a high-level diploma (see Figure S4-5 in the Online Appendix).

Table 4 – **Upward mobility characteristics – Poisson regression**

Variables	Conditions	Variable of interest and population					
		B40/T40		B40/T40 entire population		B20/T20 entire population	
		Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Gender	Male			*Reference*			
	Female	0.68***	0.04	0.69***	0.00	0.55***	0.01
Parents' capital income	Below D5			*Reference*			
	D5-D9	1.24***	0.04	1.32***	0.00	1.40***	0.01
	Above D9	1.25**	0.08	1.41***	0.01	1.85***	0.01
Type of household	Couple with 1 or 2 children			*Reference*			
	Couple with 3 or more children	0.94	0.05	0.98***	0.00	1.01***	0.01
	Single-parent family	0.87*	0.07	0.84***	0.00	0.80***	0.01
	Complex household	0.71***	0.10	0.75***	0.01	0.59***	0.02
Geographical mobility	Non-mobile			*Reference*			
	Mobile	1.10*	0.04	1.08***	0.00	1.29***	0.01
Education (parent)	Unqualified			*Reference*			
	Qualification below baccalaureate level	1.15*	0.06	1.13***	0.01	0.99***	0.02
	Baccalaureate or equivalent	1.34***	0.07	1.34***	0.01	1.35***	0.02
	Qualification above baccalaureate level	1.30***	0.07	1.29***	0.01	1.13***	0.03
	Missing			1.03***	0.04	0.94***	0.08
Immigrants (parent)	Non-immigrant			*Reference*			
	Immigrant	1.18**	0.06	1.24***	0.01	2.00***	0.02
	Missing			1.14***	0.04	1.38***	0.07
Occupation (parent)	Intermediate profession			*Reference*			
	Farmer	0.83	0.11	0.82***	0.02	0.80***	0.03
	Self-employed	1.06	0.07	1.11***	0.01	1.12***	0.03
	Manager	1.11	0.08	1.13***	0.01	1.20***	0.03
	White-collar worker	0.86*	0.06	0.88***	0.01	0.88***	0.03
	Manual worker	0.82**	0.06	0.84***	0.01	0.70***	0.02
	Other	0.99	0.10	0.94***	0.02	1.00***	0.03
Region of origin	Auvergne-Rhône-Alpes			*Reference*			
	Bourgogne-Franche-Comté	0.98	0.11	0.95***	0.01	0.92***	0.02
	Brittany	0.84	0.10	0.85***	0.01	0.88***	0.02
	Centre-Val-de-Loire	1.07	0.11	0.94***	0.01	1.050	0.03
	Corsica	0.93	0.39	1.23***	0.04	1.64***	0.09
	Grand Est	0.96	0.09	0.84***	0.01	0.74***	0.02
	Hauts-de-France	0.79**	0.09	0.79***	0.01	0.65***	0.02
	Île-de-France	1.22*	0.08	1.19***	0.01	1.51***	0.02
	Normandy	0.96	0.10	0.91***	0.01	0.82***	0.02
	Nouvelle-Aquitaine	0.98	0.09	0.87***	0.01	0.81***	0.02
	Occitanie	0.93	0.09	0.85***	0.01	0.83***	0.02
	Pays de la Loire	0.96	0.09	0.91***	0.01	0.90***	0.02
	Provence-Alpes-Côte d'Azur	0.90	0.10	0.84***	0.01	1.06***	0.02
Years	1989			*Reference*			
	1990	1.085	0.06	1.01	0.00	1.17***	0.01
	1991	1.119	0.06	1.07***	0.00	1.22***	0.01
	1992	1.147	0.08	1.13***	0.01	1.33***	0.02
	Intercept	0.30***	0.10	0.31***	0.01	0.10***	0.03
Observations		5,637		22,878		11,157	

Notes: The table indicates the risk ratio (RR) or likelihood of achieving upward mobility depending on various types of indicator between a particular modality and the reference modality (1st modality of each variable) based on a modified Poisson regression with robust variance. The "parent" indicated in the "Variables" is the parent with the highest income for the immigrant's status, the qualification and occupation, and these variables are observed between 1999 and 2012. The other variables were measured in 2010. The findings for the "entire population" correspond to the findings with all observations, without limiting the study to only non-missing data.
Sources: INSEE-DGFiP-CNAF-CNAV-CCMSA, *Échantillon démographique permanent* (INSEE's demographic panel sample) 2020. Metropolitan France. Individuals born between 1989 and 1992, included in their parents' tax return in 2010, 2011 or 2012 and who have positive or zero income in 2019, included in the annual census survey (EAR) or the population census.

Various robustness checks were performed according to the variables of interest taken into consideration, the way in which missing data was processed, the type of regression performed or even the age of the parents under consideration. Results are very close when the whole population is considered[26] but there are more significant (Table 4, column 2). One notable effect is that the Île-de-France effect becomes much more significant when the regression is performed on upward B20/T20 mobility (ratio of 1.5 compared with 1.2 for expanded mobility, Table 4, columns 2 and 3) (and to a lesser extent, when multinomial regression is performed – Figure S4-8 of the Online Appendix). The effect of being descended from immigrants also increases, as does the effect linked to parents' capital income. For information regarding the other tests, see Online Appendix S4 and Abbas & Sicsic (2022).

3.2. Analysis of Downward Mobility

As for upward mobility, we use a Poisson regression to explain downward T40/B40 mobility (probability of the top 40% falling into the bottom 40%). The findings (see Figure S4-10 in the Online Appendix) are generally the inverse of the findings for upward mobility, with some differences. Women, single-parent families and complex households have a higher probability of experiencing downward mobility, as do immigrants. The latter finding regarding immigrants is therefore not symmetrical with the finding for upward mobility.

Having parents with high capital incomes or who have completed higher education is protective against downward mobility. Unlike with upward mobility, geographical mobility during childhood and the occupation of parents have no impact on downward mobility. Across the whole population, the findings are similar, but more significant: for example, the fact of having capital income or holding a high-level diploma offers greater protection against downward mobility (see Figure S4-11 of the Online Appendix).

* *
*

This article gives, for the first time, a direct estimate of intergenerational income mobility in France based on data that matches individual income in 2019 to parents' income a decade earlier. When measured in this way, the intergenerational mobility at the individual income level appears to be higher than in the United States and Italy, and close to that observed in Australia when life cycle bias is corrected for. However, it appears to be lower than in Switzerland, Sweden, Denmark and Canada. The wealth of data used allows us to demonstrate that, all else being equal, upward mobility is even more pronounced when the parents have high capital incomes, when the parent with the highest income has a level of education at least equal to the baccalaureate, when they are an immigrant and when their family was geographically mobile during their childhood. Conversely, the fact of being female, having lived in a single-parent family or in a family in which the reference person is a manual worker and being resident in Hauts-de-France has a negative impact on upward mobility. Persons from Île-de-France and the bottom 20% of the income scale are more likely than others to experience upward mobility. This effect is linked to the attractiveness of Île-de-France, together with the opportunities the area offers in terms of higher education and jobs. Children of immigrants have also an elevated risk of downward mobility, and sticky floor.

It is important to remember that these finding relate to persons between the ages of 27 and 30. Although almost all of these young adults are in employment, their income at this age is not their permanent income, which may have an (upward) impact on certain mobility indicators. However, the existing literature leads us to believe that this effect is minor for the statistics that we use (upward mobility is very similar at 29 and 35 years of age), especially when coupled with the very low intragenerational mobility in France (particularly when compared to the United States) (Loisel & Sicsic, 2023). It will be interesting to update these initial findings when similar data will be available for children aged between the ages of 35 and 40. This new database can also be used to measure inequality of opportunities in France (Roemer & Trannoy, 2016). □

26. In other words, not limited to individuals included in the population census data: it is therefore necessary to add a 'missing' category for the population census variables.

Link to the Online Appendix:
www.insee.fr/en/statistiques/fichier/7661155/ESpreprint_Sicsic_OnlineAppendix.pdf

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Does Offshoring Still Play a Role in the Decline in Manufacturing Employment?

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Abstract – Government authorities and the media regularly show great interest in offshoring due to its role in manufacturing employment's decline, in particular. However, it remains difficult to quantify company offshoring given that it can be defined in multiple ways. This article updates the literature's previous research while proposing a new and improved methodological framework for identifying offshoring, based on machine learning methods applied to INSEE's *Chaînes d'activité mondiales* (CAM) survey. Our analysis, which covers 1995–2018, shows that the number of offshoring companies has decreased slightly following the global financial crisis of 2009. We show that offshoring is procyclical and describe the characteristics of the offshored jobs and offshoring companies. A causal econometric estimate of the annual average number of jobs offshored indicates offshoring's continuing macroeconomic influence on the dynamics of French manufacturing employment.

JEL: F23, F66
Keywords: offshoring, manufacturing, global value chains, supervised learning

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Since 1974, the manufacturing sector has fallen dramatically in France. It accounted for just 3.2 million jobs in 2018, compared with 5.8 million in 1974. Part of this decline can be ascribed to offshoring, a phenomenon whereby companies transfer capital or jobs to regions that give them a competitive advantage. Although offshoring does not affect the tertiary sector to the same extent as the manufacturing sector, certain service activities in the tertiary sector are also offshored, e.g. call centres.

Since the early 1990s and the "Hoover" affair (Chanteau, 2003),[1] offshoring has been a repeatedly discussed phenomenon, making it a "public problem", as defined by Gusfield (2009). However, it remains difficult to quantify. Despite this, many studies have already demonstrated that offshoring accounts for the loss of only around several tens of thousands of jobs each year, with figures varying depending on estimates. Offshoring is therefore nowhere near the only reason for the de-industrialisation of French employment (Demmou, 2010), which can also be explained by increased productivity or the outsourcing of certain tertiary sector operations.

However, its impact on the economy may outweigh the direct job losses it causes. Jennequin *et al.* (2017) show that, at local level, offshoring can cause asymmetric shocks that destabilise the local economy. The ensuing fragmentation of value chains can also constitute a vulnerability for all downstream sectors, as Gerschel *et al.* (2020) demonstrated using the example of the shock generated by the COVID-19 pandemic in China.

Quantifying the scale of offshoring therefore continues to constitute a scientific barrier to understanding our economies, which the COVID-19 pandemic revealed to be dependent on international value chains. This is nevertheless a complex task that hinges on the methods and definitions adopted, and the fact that the methods and definitions adopted by previous studies differ makes it difficult to make geographical, sectoral and time comparisons. The aim of this article is to contribute to this literature by quantifying offshoring's economic impact in France between 1995 and 2018 using updated and standardised methods.

Section 1 of the article sets out the literature on offshoring and its contribution to the decline in manufacturing employment. Section 2 introduces the data used, namely the INSEE *Chaînes d'activité mondiales* (CAM) survey. This survey asks a sample of companies about any offshoring undertaken between 2009 and 2011. We also use accounting and customs data. We construct an offshoring detection model and use the data from the CAM survey for the three-year period 2009–2011 to derive estimates for that model. We then use this model to quantify the annual number of relocations[2] over the 1995–2018 period – assuming that the offshoring predictors are constant (Section 3). Our findings are presented in Section 4. These include the evolution of offshoring, the most significantly affected sectors and company size categories, and the most frequent offshoring destinations. Section 5 focuses on estimating offshored employment and describing the characteristics of these jobs.

1. Literature Review

1.1. Definition-related Challenges

Many different approaches are used to understand offshoring, due to multiple possible definitions as much as multiple methodologies adopted.

Offshoring is a concept open to various interpretations. Fontagné & Lorenzi (2005) therefore strictly define offshoring as "the closure of a unit of production in France, followed by a reopening abroad in order to re-import goods to the national territory for a lesser cost and/or to continue to participate in export markets with this new unit of production". Under this definition, offshoring consists of the closure of an establishment, the downsizing of its workforce employed in France, and the creation or consolidation of a subsidiary abroad.

However, a broader definition is necessary to take outsourcing into account. This has been a feature of certain business strategies for several decades and consists of a production company transferring and entrusting certain activities to a supplier or subcontractor. This aspect has been incorporated by Aubert & Sillard (2005), who define offshoring as the "substitution of domestic production by foreign production resulting from the arbitration of a producer who gives up producing in the country of origin to produce or subcontract abroad". This is the definition explicitly used in the questionnaire for INSEE's CAM survey. That questionnaire defines activity

1. In 1993, Hoover, a subsidiary of the US Maytag group, transferred the operations of its facility in France to a factory in Scotland, which resulted in the loss of 600 jobs. The incident received widespread media coverage and has been firmly established in France as the benchmark example for offshoring (Chanteau, 2003).

2. In this article, we will focus only on relocations that correspond to offshoring behaviour (thus excluding changes in already offshored production sites or reshoring behaviour).

offshoring as the "total or partial transfer of the activity from France to another country, where the activity was previously carried out by the company itself or by another company (a subcontractor, for example)". This article applies this definition, for practical purposes.

1.2. Methodological Challenges

Demmou (2010) suggests that relocations be quantified by measuring the impact of commercial trade on manufacturing employment: this would be done by estimating the effects of trade balance variations on manufacturing employment for the trade in question. However, she obtains relatively divergent results depending on whether she applies an accounting approach, which she considers to be a lower bound (foreign trade would explain 13% of manufacturing job losses between 1980 and 2007, equivalent to 9,000 manufacturing job losses per year), or an econometric approach (changes in foreign trade would explain 39% of manufacturing job losses), which is a "fairly inaccurate estimate", according to the author.

Other econometric approaches use macroeconomic or sectoral data to quantify the effect of offshoring: Malgouyres (2018) measures the effects of international trade on employment and demonstrates that, between 2001 and 2007, 13% of manufacturing job losses can be explained by competing Chinese imports, representing a loss of 90,000 jobs in the manufacturing sector and 190,000 jobs in other sectors.

Aubert & Sillard (2005) identify offshoring on the basis of establishment-level data: they detect offshoring whenever a given establishment's employment declines or disappears and that establishment's group more frequently imports goods previously produced in France. Similarly, the method used in this article is based on identifying "presumptions of offshoring". We replicate the method put forward by Aubert & Sillard (2005) for comparison purposes. We have also used other indirect quantification methods based on an analysis of changes in imports (De Gimel, 2005) or of changes in the workforce of non-domestic subsidiaries (Drumetz, 2004).

These authors may follow differing approaches, yet they all conclude that offshoring's macroeconomic impact is relatively minimal in terms of both offshored jobs and operations. According to Aubert & Sillard (2005), approximately 95,000 manufacturing jobs were eliminated in France between 1995 and 2001 as a result of offshoring overseas, which equates to an average of 13,600 jobs per year (or up to 19,300 according to their worst-case scenario). This figure is only 6,600 per year according to Fontagné & D'Isanto (2013), who define offshoring more restrictively.

Leading forecasts available for France estimate the annual number of job losses resulting from offshoring to fall between 6,000 and 13,500 (Table 1). Although this might suggest that offshoring's macroeconomic impact is limited, these jobs are likely to be in a specific region or business sector and therefore their loss triggers asymmetric shocks, disrupting global value chains even more as they become increasingly complex.

Table 1 – **Main studies estimating the number of French company relocations**

Study	Method	Coverage and period	Findings
Aubert & Sillard (2005)	Presumptions of offshoring based on workforce downsizing and increase in imports	Industry (1995–2001)	13,600 jobs per year
Demmou (2010)	Macroeconomic approach		9,000 jobs per year
Bonnal & Bouba-Olga (2011)	Analysis of investment and divestment operations in France	2009–2010	7,250 jobs per year
J. Arthuis (2005)	Estimates based on personal interviews extrapolated using sector-specific imports	2006	8,000 jobs
Fontagné & D'Isanto (2013)	Use of CAM statistical survey	2009–2011, companies with more than 50 employees	6,600 jobs per year
Lécrivain & Morénillas (2019)	Use of CAM-PME statistical survey	SMEs with more than 50 employees, 2014–2016	300 jobs per year
Chanteau (2008)	Documentary monitoring (Bref Rhône-Alpes print magazine, Bodacc (Official Civil and Commercial Advertising Newsletter, weekly surveys))	Rhône-Alpes, 1993/1997/2003	0.15 % of establishments per year

It is unfortunate that the same method has not been reproduced with regularity as this would have made it possible to monitor offshoring trends over time. Comparability is restricted by the sheer number of methods and scopes forming the basis for estimates. Equally, since minimal comparisons exist between methods under a given scope, those methods cannot be calibrated according to their tendency to overestimate or underestimate the phenomenon of offshoring.

2. Data

2.1. The CAM Survey and Offshoring Measurements

INSEE's 2011 *Chaînes d'activité mondiales* (CAM) survey questioned a sample of approximately 6,500 companies about any offshoring operations they may have carried out between 1 January 2009 and 31 December 2011.[3] The survey covers legal units (companies) that are active, commercial and operational as at 31 December 2012, employ at least 50 workers at the end of 2008, are based in France and carry out a principal activity classified in the sectors corresponding to sections B to N (excluding K) of the Nace Rev.2 nomenclature, i.e. all manufacturing, construction and trade activities, plus most other service activities, with the exception of finance and insurance activities.

The survey defines offshoring as a "transfer of national production abroad [capable of] taking various forms: a transfer to a subsidiary based abroad; a transfer to a company belonging to another group, which is not a subsidiary and is based abroad; a transfer to a company based abroad that does not belong to the offshoring company's group; a transfer from a domestic subcontractor to a non-domestic subcontractor". Although this definition is somewhat broad as it includes subcontracting, unlike the definition used by Fontagné & Lorenzi (2005), it is still a less extensive definition than that used by certain authors, such as Arthuis (1993), who includes "non-localisation".

Descriptive statistics on activities offshored between 2009 and 2011 as measured by the CAM survey are presented in Fontagné & D'Isanto (2013): 4.2% of the legal units included in the sample relocated between 2009 and 2011. These authors argue that large enterprises, exporting companies, companies in the manufacturing and information and communication sectors and companies with subsidiaries abroad offshore their activities more often than other types of companies.

2.2. Additional Data

We additionally rely on data from three other sources in order to obtain annual information about company characteristics, namely INSEE's *Fichier approché des résultats d'Esane* (FARE), annual structural statistics of companies from the ESANE scheme with accounting information derived from French company tax returns, consistent with the information provided in the *Enquête sectorielle annuelle*; customs data relating to French company imports;[4] and ILO (International Labour Organization) data concerning average wages in various countries.

Drawing inspiration from the work of Aubert & Sillard (2005), we calculate rates of change in various company characteristics over the three-year period 2009–2011.

We end up with four groups of explanatory variables:

- Ratios reflecting change in accounting variables and the rate of change in employment (over the three-year period);
- Ratios reflecting change in customs variables (over the three-year period);
- Size (3 categories) and sector (5 categories) dummies[5] (prior to the three-year period);
- (Prior) wage ratios comparing the average wage in France with the average wage in the country from which the legal unit imports the most (total or specific) goods after the three-year period.

Figures I to III show the distribution of the three explanatory variables with the greatest explanatory power in the models estimated in Section 3.

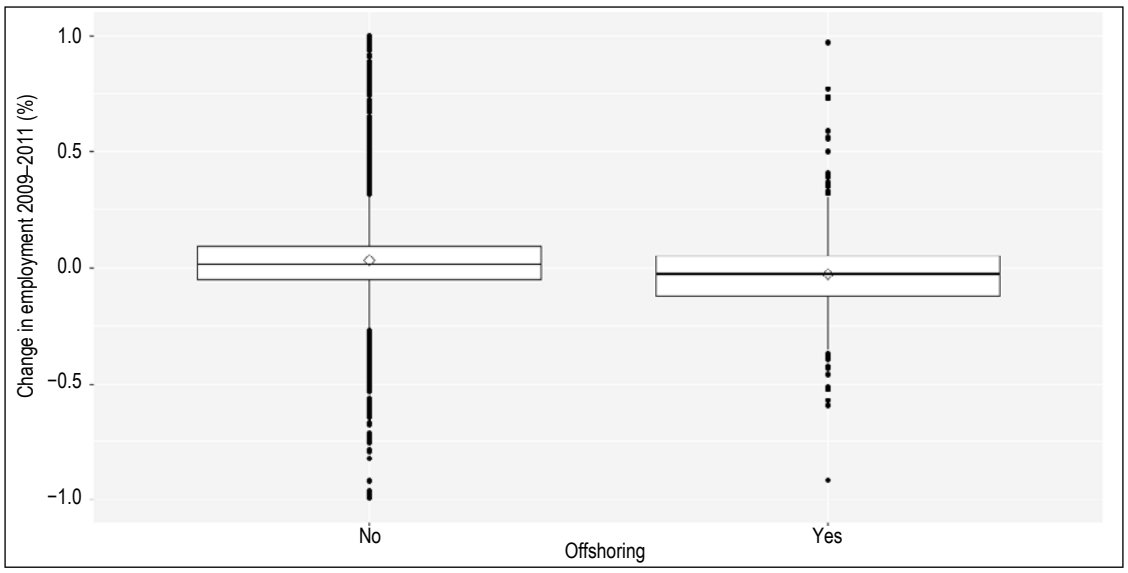
In line with the intuition of Aubert & Sillard (2005), Figure I reveals that companies that have offshored activities exhibit a negative employment trend, on average, whereas the average trend for companies that have not offshored is slightly positive. Similarly, the first and third quartiles and the median of the distribution of

3. Question S2Q3. We group cases of planned yet incomplete offshoring together with cases of offshoring not being carried out.

4. This data is inherently deficient for studying offshoring: a number of intra-European flows are incorrectly recorded despite various adjustments having been made. The methodological challenge of this article is to bypass this limitation by combining the customs variables with other explanatory variables. This combination of variables is what will enable offshoring to be predicted with greater accuracy. For customs variables, we distinguish between imports of specific goods and total imports of goods: specific goods are defined as goods that correspond to the company's principal activity.

5. BE (manufacturing)/FZ (construction)/GI (trade, transport, hotels and restaurants)/JKL (information and communication, finance, real estate)/MN (professional, technical, scientific and administrative and support service activities).

Figure I – **Rate of change in employment according to the existence of offshoring**



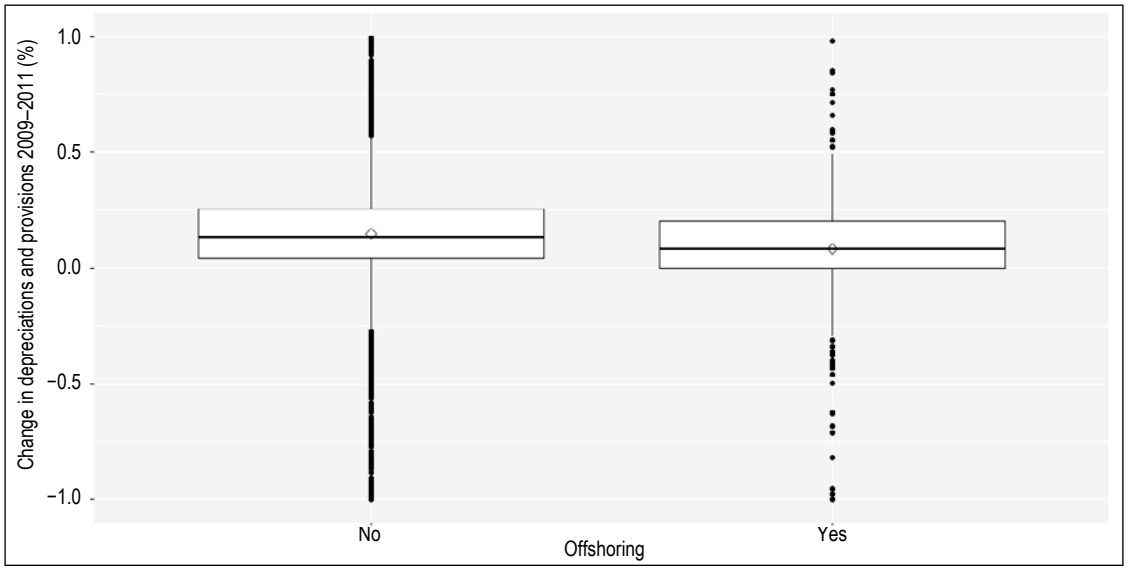
Note: Figures I, II and III are box plots illustrating the distribution of explanatory variables. A rectangle is drawn between the first and third quartiles and intersected by the median. The "box" thus produced is completed by a segment, the ends of which represent the upper and lower adjacent values of distribution.
Source: CAM survey, FARE, INSEE.

changes in employment are higher for companies that have not offshored than for those that have, even if there is an overlap between the two distributions.

On average, companies that offshored some of their activities in 2009–2011 see their depreciation, amortisation and provisions increase by less than other companies (Figure II). In accounting, depreciation and amortisation are used to account for the wear and tear, ageing and usage of an asset (a machine or vehicle, for example). To streamline an asset's potential renewal, a deduction corresponding to this wear and tear is booked against the asset's value each year. Similarly, provisions record the depreciation of inventoried equipment and are deducted from the income statement. One possible reason for depreciation, amortisation and provisions increasing less for offshoring companies could be weakened investment in material assets ahead of the offshoring of certain activities.

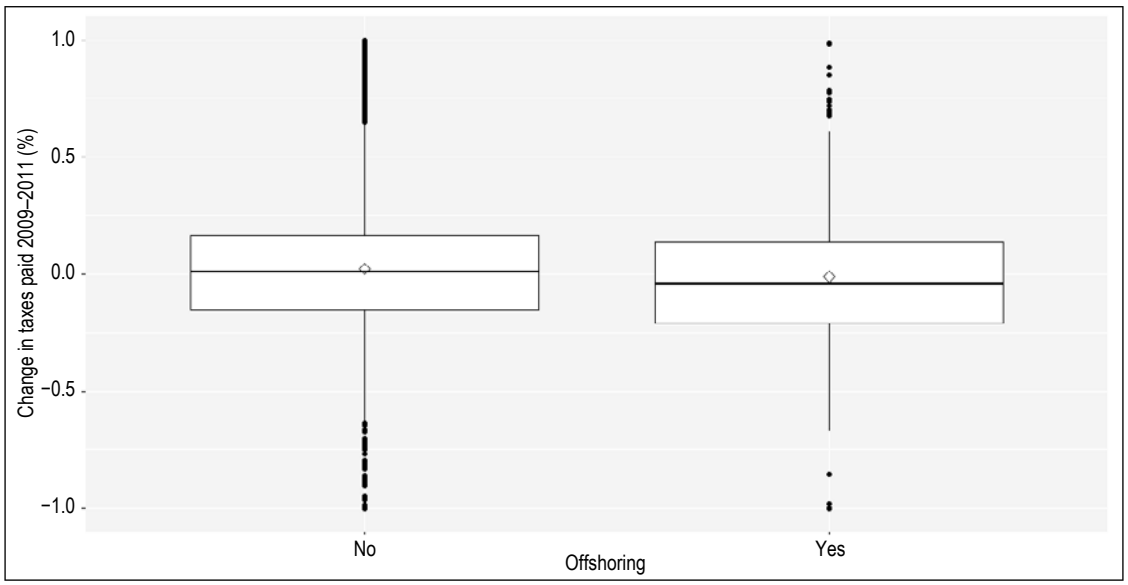
Similarly, on average, taxes paid in France fall for companies that have offshored, whereas they rise modestly for non-offshoring units (Figure III). This can be explained by the reduced volume of production in France in the wake of offshoring.

Figure II – **Rate of change in depreciations and provisions according to the existence of offshoring**



Source: CAM survey, FARE, INSEE.

Figure III – **Distribution of changes in taxes paid in France (%) according to the existence of offshoring**



Source: CAM survey, INSEE.

Table 2 shows the conditional correlations (calculated *via* logistic regression) between the existence of offshoring and some explanatory variables used in the models presented in Section 3. The fact that the learning models include possible non-linear effects explains the non-significance of the logistic regression coefficients for certain prediction variables.

So, although we cannot use logistic regression to identify potential causal effects, it does make it possible to describe offshoring companies in the CAM survey sample accurately: these are the companies for which, all things being equal, we observe an increase in production, financial investment and staff numbers, as well as a decrease in imports, production-related taxes and tangible assets. The positive correlations between the act of offshoring and changes in the number of employees and production volumes sold, which might seem counter-intuitive, can be explained by offshoring companies generally being developing organisations with funds to invest. This idea is explored further in Section 4.2.

3. Offshoring Detection Strategy and Model

Here, we propose a strategy that involves calibrating a model for predicting offshoring based on data on relocations that have actually been observed. Once calibrated, the model is used to predict offshoring over periods during which we do not observe relocations. We compare the performance of different models in order to select the most accurate one.

3.1. Looking Beyond Aubert & Sillard

By virtue of its microeconomic approach and scale, Aubert & Sillard's study (2005) has now become the benchmark for quantifying offshoring in France. Using their model, the authors can detect a "presumption of offshoring" whenever a company sees a decline in employment of more than 25% accompanied by increasing imports of specific goods (in proportion to the shutdown of production in France).

We can test the relevance of their offshoring identification model on companies that responded to

Table 2 – **Logistical model: conditional correlations with existence of offshoring**

Variable	Correlation	p value
Change in production sold	+	<0.0001
Change in financial investment	+	0.0007
Change in number of employees (natural persons)	+	0.0022
Change in value added	-	0.044
Change in imports of specific goods	-	0.43
Change in production taxes	-	0.81
Change in tangible assets	-	0.96

the CAM survey. In Figure IV, each dot corresponds to a company in the CAM survey. Dark grey dots indicate offshoring units and light grey dots indicate non-offshoring units. The axes correspond to the two explanatory variables used by Aubert & Sillard (2005): presumptions of offshoring according to their model therefore appear in the lower right quadrant.

Contrary to the assumptions made by Aubert & Sillard (2005), many companies have actually managed to offshore activities without experiencing a decline in employment and an increase in their imports of specific goods. There are several possible reasons for this:

- Our evaluation focuses on companies, and offshoring is most frequently carried out by companies with multiple establishments. A company may well have offshored an establishment and yet have recruited staff in other establishments, leading to a positive trend in total employment;

- The underlying global economic depression between 2009 and 2011 is certainly a factor in the decline in employment, including for non-offshoring companies;

- Imports of specific goods may not increase after offshoring if this corresponds to a production link that is not a feature of the company's principal activity. They also may not increase if the specific imports are consequently handled by a French subcontractor whose business with the offshoring company does not appear in the customs data.

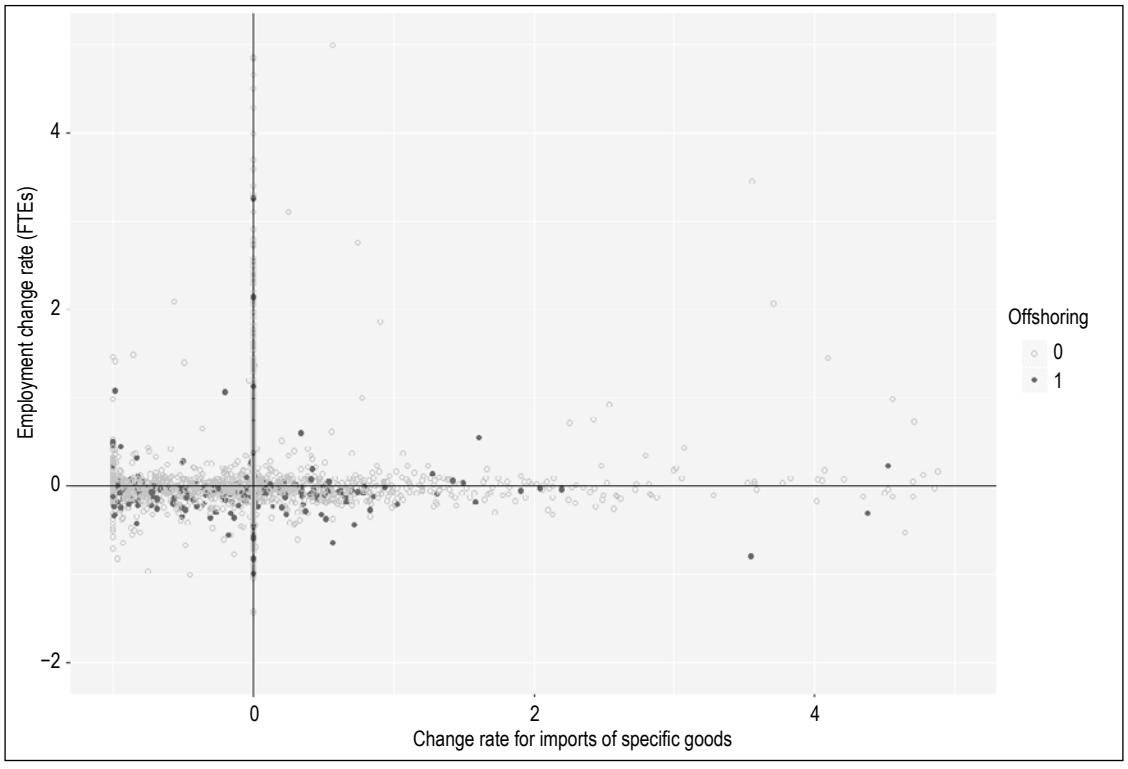
While this graphical representation does not necessarily render the method used by Aubert & Sillard (2005) invalid, the development of the statistical models described below does allow for a more granular analysis and a more accurate prediction of offshoring.

3.2. Model Selection

The data on actual offshoring provided by the CAM survey makes it possible to extend the methodology of Aubert & Sillard (2005) and apply it to other explanatory variables (presented in Section 2.2).

The CAM survey's offshoring variable is used here as an explained variable in order to train the prediction models. These models can be used to apply the results from the three-year period (2009–2011) to a longer period. The CAM survey's sampling method, which has been designed to be representative of the

Figure IV – **Offshoring according to changes in employment and imports of specific goods (2009–2011)**



Coverage: Companies in mainly commercial sectors, excluding agriculture and finance, employing at least 50 workers at the end of 2008.
Source: CAM survey, INSEE.

coverage,[6] goes some way to justifying such a generalisation.

We are therefore creating an offshoring detection model based on numerous potential explanatory variables, the influence of which on offshoring will be estimated using a range of prediction models. We have selected the following models:

- logistic regression, with an additional log-logistic link function (to capture asymmetry effects) and stepwise AIC selection of explanatory variables;

- random forest, with 1,000 trees and 20 variables randomly retained for the selection of each node (from 30 explanatory variables);

- XGBoost forest model (boosting on CART, learning rate of 1, consideration of unequal sample composition in terms of offshoring, maximum tree depth of 20, a single boosting iteration, sub-sample of 0.63, and 3,000 trees launched in parallel);

- implementation of the method used by Aubert & Sillard (2005), with thresholds being multiplied (rather than arbitrarily selecting a single threshold as in their initial methodology) – which makes it possible to estimate optimal thresholds.

These algorithms were configured by comparing their predictive performance. For the sake of simplicity, we have only selected the algorithm with the best performance within each model family.

To estimate each of these models, we divide the CAM survey sample into two sub-samples. The first sub-sample, which comprises 90% of the legal units that responded to the survey, is used to select the model. This is also divided into two samples (a "learning" sample, comprising 80% of these legal units, and a test sample, comprising the remaining 20%) in such a way that both of them have the same proportion of offshoring legal units. The models are estimated or "trained" using the learning sample, and their predictive performance is compared using the test sample. The second sub-sample is known as the validation sample (10% of legal units that responded to the survey). This is kept for the purpose of making unbiased estimates of the prediction scores for the model ultimately selected. All the explanatory variables presented in Section 2.2 are used as inputs for each model.

Figure V shows the relative performance of these models using ROC curves,[7] and Table 3 shows the Areas Under the Curve (AUC) in connection with this.

The random forest model has the largest AUC, covering most of the convex hull of the ROC curves: this is the model with the best predictive performance. As such, we use this model from this point onwards in the article.[8] Incidentally, the specificity of the FARE 2008 data means we have to create a random forest with several fewer variables for the 2008–2010 and 2006–2008 three-year periods, but the AUC for this falls only by a few percentage points (see the second column of Table 3).

Figure V demonstrates that the model proposed by Aubert & Sillard (2005) was well founded, but could be improved. Although the dotted line associated with their model is indeed higher than the first bisector (AUC score: 0.54), its predictive performance is below that of models which include more explanatory variables and allow those variables to be freely combined. Our

6. Stratified sampling is used: 213 strata obtained by cross-referencing sector and workforce class, with "systematic" random sampling within each stratum. Legal units with more than 250 employees were surveyed comprehensively because of their economic relevance (they account for 61.3% of the units in the sample).

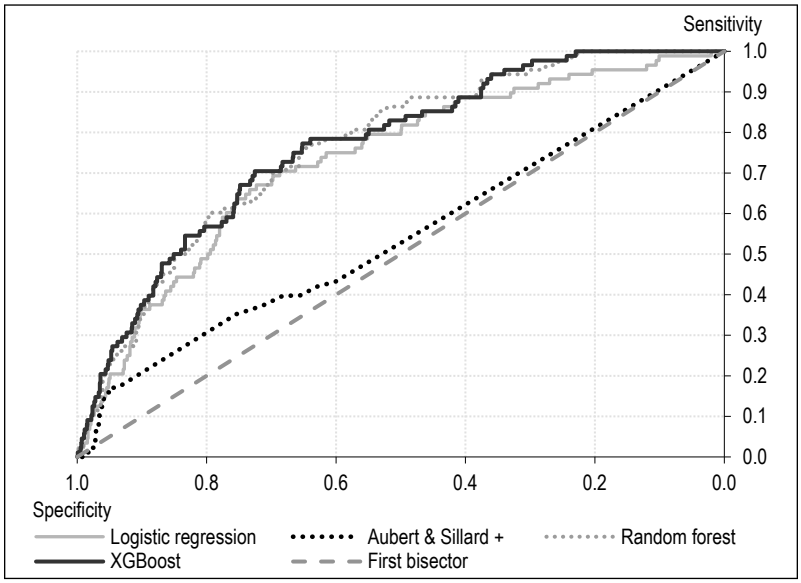
7. ROC (receiver operating characteristic) curves are graphs that make it possible for the predictive performance of different models to be compared. In Figure V, each model is represented by a curve. At this stage, each model returns a probability of offshoring for each company in the test sample. Based on the discriminatory threshold used (above which offshoring is determined, and below which no offshoring is determined), the model will have varying levels of specificity and sensitivity (i.e., the ratio of true negatives to true negatives and false positives, and the ratio of true positives to true positives and false negatives). In the lower left quadrant: maximum specificity and zero sensitivity. The discriminatory threshold is set at 1, so there are no positives (and therefore no false positives, so a specificity value of 1). In the upper right quadrant: the sensitivity value is 1 and the specificity value is zero. The discriminatory threshold is set at 0. The challenge therefore lies in selecting a discriminatory threshold and a model that strike an acceptable balance between specificity and sensitivity. Curves closest to the upper-left corner will provide the best prediction results. The area under the ROC curve (AUC) is a score that varies from 0 to 1 and quantifies this predictive performance. Preferred AUC values are those that exceed 0.5 (the first bisector corresponds to the pure chance model).

8. Subsequently, some of the results will use prediction percentage confidence intervals, established using the infinitesimal jackknife method: see Wager et al. *(2014) and Mentch & Hooker (2016).*

Table 3 – **Predictive performance of models (AUC values)**

	AUC	AUC (2008 model)
Logistic regression (cloglog, stepwise)	0.73	0.73
Random forest	0.80	0.78
XGBoost	0.78	0.77
Aubert & Sillard's method	0.54	0.54

Figure V – **ROC curves for predicting offshoring**



Note: To achieve a specificity of 0.8, the logistic regression model predicts offshoring with a sensitivity value of 0.5.
Source: INSEE, FARE and CAM – DGDDI, Customs.

selected model therefore predicts offshoring more effectively than theirs.

3.3. External Validity Tests

The selection of our model is therefore based on offshoring observed between 2009 and 2011. Use of this model to predict offshoring over the entire 1995–2018 period is predicated on a strong assumption that the offshoring predictors are constant. However, the underlying general economic conditions between 2009 and 2011 are unusual in that this period is a recession, during which offshoring patterns are potentially idiosyncratic. Yet when this study was carried out, there were no data available to make comparisons with other periods: the CAM 2020 survey, which would go on to cover offshoring in 2018–2020, was not yet available. We are therefore forced to retain our prediction models which were estimated during a period of underlying global economic depression, meaning we run the risk of incorrectly extrapolating unusual characteristics from the learning sample (termed "overfitting" in machine learning literature). The validity at other points in time (external validity) of the random forest model we have selected can be tested to some extent.

First, we compare the offshoring company sample derived using our model with the actual offshoring database maintained by the information monitoring company, Trendeo. This database is largely incomplete as it is constructed using documentary monitoring of the daily and regional press. Despite this, we can assume that every relocation recorded in this database is genuine (even if definition-related issues still remain) and check how many of these relocations our model predicted. Over the 2009–2018 period (the common base shared by our study period and the Trendeo database), our random forest model correctly recorded 78% of the relocations identified by Trendeo as offshoring. This is a reassuring outcome for the purposes of calculating the macroeconomic flows associated with offshoring (Section 4) because large enterprises inevitably account for a significant proportion of the aggregated values.

Second, we are using the 2016 CAM-PME survey, a special version of the CAM survey which covers only SMEs with more than 50 employees. By using this sample to estimate our random forest model, our predictions are limited to just 20% of actual relocations (compared with a peak of 42% using 2011 CAM data, see Section 3.4). The AUC score calculated using this CAM-PME sample is only 0.58.

These two tests therefore provide mixed results: our model's predictive performance based on the Trendeo database is good, but that performance is average at best when the CAM-PME database is used. How do we interpret this? Some of the variations in performance are likely to be associated with the size of the companies: our model manages to recognise the most obvious instances of large manufacturing sites being offshored, which were reported by the press and therefore appear in the Trendeo database. However, it has a harder time detecting instances of SME

offshoring, which are recorded by CAM-PME. This size-related effect is certainly compounded by a cyclical effect, linked to changes in the underlying general economic conditions between 2009–2011 and 2014–2016 (periods over which companies were questioned in the CAM and CAM-PME surveys, respectively), and it is impossible to distinguish between them.[9]

3.4. The Random Forest Model Selected

Figure VI shows two importance scores for the different explanatory variables in the random forest.[10] The higher the score, the more the variable contributes to the identification of offshoring. In descending order of contribution, the variables are: change in employment (natural persons); originating country for imports of specific goods *ex post*; change in depreciation, amortisation and provisions; change in taxes paid in France; and business category.

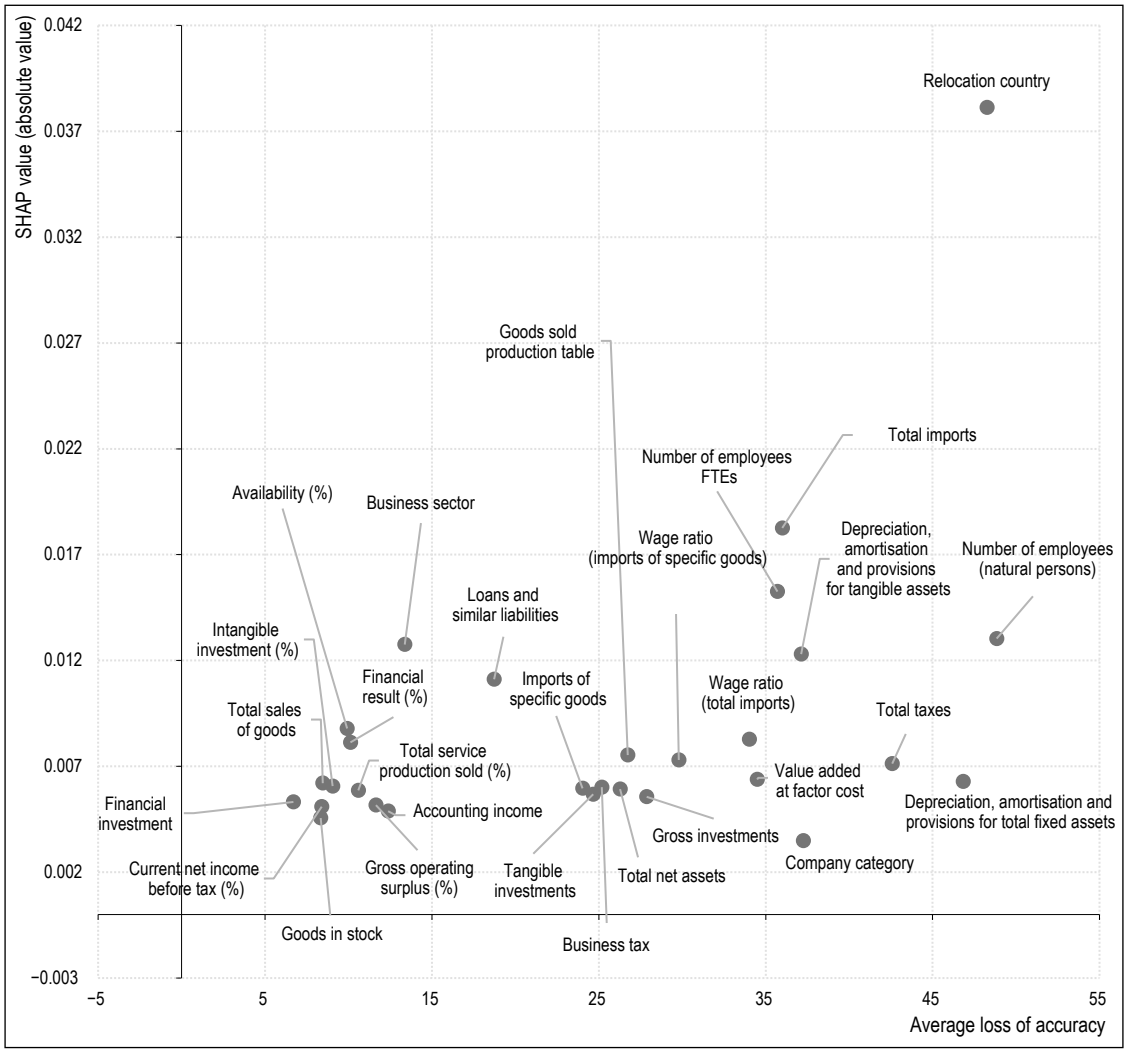
The random forest model does however struggle to predict offshoring with certainty (none of the estimated probabilities for offshoring exceeds 0.6). In addition, when using the test sample, the model predicts that many relocations have occurred for companies when this is not the case (false positives).

We therefore look at the following three scenarios to determine whether a company has offshored its activities. With a view to estimating the correct number of relocations (i.e., 6.1% of companies

9. In this respect, predictive machine learning methods are no substitute for cyclical official statistics surveys. That was somewhat the premise of this article: to overcome the lack of annual offshoring surveys by extrapolating results from a one-off survey (CAM). The external validity tests carried out on Trendeo and especially CAM-PME demonstrate the challenges inherent in such a premise.

10. The score depicted on the horizontal axis indicates the predictive quality loss if the variable were removed from the set of explanatory variables. The score depicted on the vertical axis is the SHAP value, which indicates each variable's contribution to the forecasting output.

Figure VI – **Importance of explanatory variables in the random forest**



Note: The most important variable in the model in terms of its impact on average loss of accuracy is FTE change because its removal as an explanatory variable reduces average accuracy by 48.8.
Source: INSEE, FARE and CAM – DGDDI, Customs.

in the test sample), the central scenario sets the probability threshold above which a company will be considered to be an offshoring company. This is therefore a plausible scenario in terms of predicting the number of relocations. However, it is liable to overfitting. Two additional scenarios are introduced, one to predict 50% fewer relocations (low scenario), and one to predict 50% more relocations (high scenario), both in the test sample. The probability thresholds above which offshoring is considered to have occurred are 0.154 for the low scenario, 0.217 for the central scenario and 0.285 for the high scenario.[11]

The percentages of correct predictions among predictions of offshoring are higher in the low scenario (Table 4). We will therefore use this method when we need to obtain more precise information about the characteristics of offshoring (in terms of sector, company size, etc.), without attempting to estimate the exact number of relocations.

Table 5 shows different prediction quality scores under the three scenarios: the high scenario manages to return 42.0% of actual relocations, albeit at the expense of a loss of specificity, whereas the low scenario offers a high level of specificity (97.5%), but returns fewer actual relocations (17.0%).

4. Predicted Offshoring Results

4.1. Manufacturing Relocations, Primarily to Europe

Using the variables in the model, each company is assigned a probability of offshoring over the three-year periods[12] starting from 1995–1997 and concluding with 2016–2018, by means of the random forest model. A presumption of offshoring or no offshoring is then assigned depending on the (low/central/high) scenarios and their confidence intervals, which have different offshoring prediction thresholds.

The number of relocations in a given year is calculated as the average of presumed relocations over the three three-year periods that include that year.

Over the 1995–2018 period, an annual average of approximately 1,000 companies are estimated to have offshored in the central scenario – either by closing one of their production sites in order to shift production outside of France, or by substituting foreign production for a domestic subcontractor (Figure VII). The low and high scenarios frame this estimate (approximately 500 companies offshoring each year in the low scenario, and 1,750 companies in the high scenario). We also see a decline in annual offshoring volume (−25%) following the 2009 crisis (the annual average is 980 over the 1995–2005 period, and 730 over the 2010–2018 period).

Three quarters of these companies are SMEs, approximately one quarter are intermediate-sized enterprises (ISEs), and large enterprises (LEs) account for less than 1% of the companies

11. For the model based on the three-year periods of 2006–2008 and 2008–2010, the thresholds are 0.225 (central scenario), 0.294 (low scenario), and 0.150 (high scenario).

12. The evaluation follows a three-year cycle to mirror the CAM survey's design: the question featuring in the survey questionnaire (and on which the prediction models are trained) asks companies about the occurrence of any offshoring in the last three years.

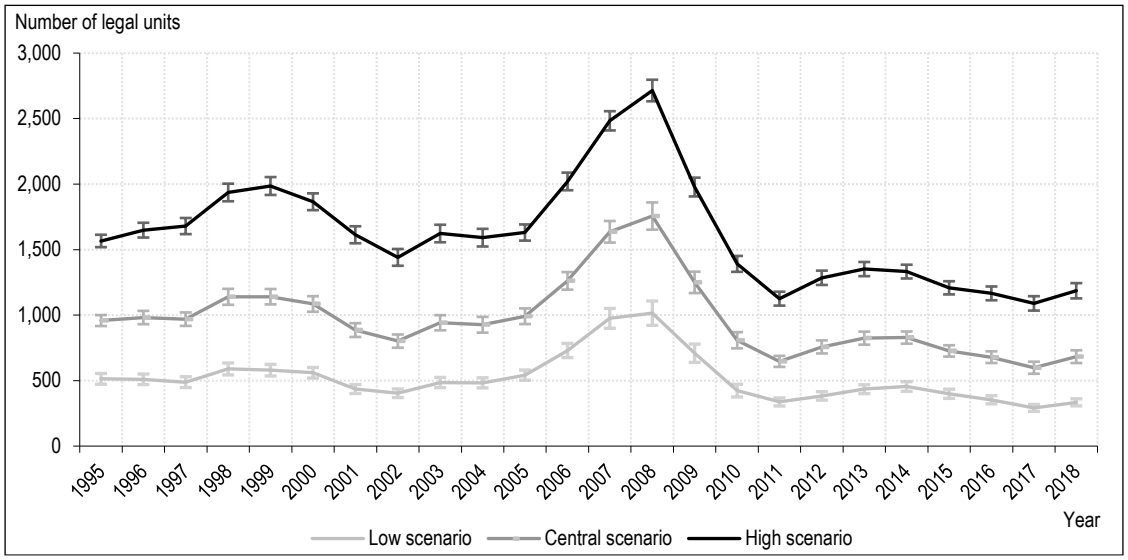
Table 4 – **Prediction model confusion matrix (in total percentages)**

	Lack of offshoring in practice	Actual offshoring in practice
Estimation of non-relocation in the low scenario	90.7	2.1
Estimation of relocation in the low scenario	6.0	1.1
Estimation of non-relocation in the central scenario	88.7	4.0
Estimation of relocation in the central scenario	5.4	1.8
Estimation of non-relocation in the high scenario	85.9	6.9
Estimation of relocation in the high scenario	5.0	2.1

Table 5 – **Model prediction quality scores (in percentages)**

	Low scenario	Central scenario	High scenario
Sensitivity	93.8	94.3	94.5
Specificity	35.0	30.5	23.2
Average accuracy	91.8	90.5	88.0
Kappa score	18.2	22.5	19.5
F1 score	95.7	95.0	93.4

Figure VII – **Annual breakdown of legal units predicted to have offshored activities**



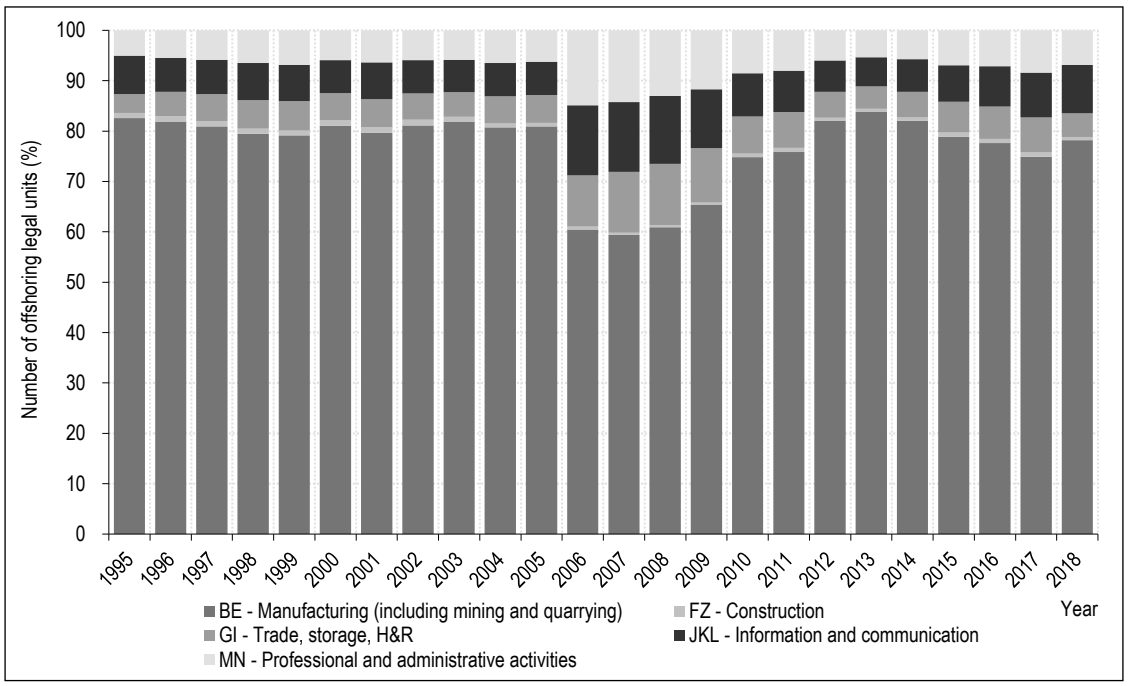
Source: INSEE, FARE and CAM – DGDDI, Customs.

predicted to be offshoring their activities. If we weight each company by its employment, each category (SMEs, ISEs, LEs) accounts for a third, on average, over the 1995–2018 period.

Figure VIII provides a sectoral breakdown of companies predicted to have offshored their activities, for the low scenario.[13] It comes as no surprise that manufacturing accounts for a significant proportion of predicted relocations. This is the sector most affected by the extension of global value chains. Hanson (2017) shows that the phenomenon of offshoring affects a small number of sectors within the manufacturing industry. One example is the auto industry, which has been continually adapting to a rapidly changing international market since the late 1990s. This adaptation has notably led to an internationalisation of value chains across different hubs in North America, Europe and

13. In this scenario, the probability that the company predicted to have offshored its activities has actually done so is higher than in the other two scenarios, which means that the sectoral breakdown is more reliable.

Figure VIII – **Sectoral breakdown of offshoring legal units (low scenario)**



Source: INSEE, FARE and CAM – DGDDI, Customs.

East Asia. Production then combines part and component manufacturing in low-wage countries with assembly in high-wage countries. Despite the rising trend in offshoring within the sector between 2000 and 2016, a large proportion of relocations to countries with low production costs is undertaken by a handful of manufacturing groups. Head & Mayer (2019) show that the five groups with the highest levels of offshoring account for half of all relocations during that period.

Alongside this manufacturing weight, which partly reflects the internationalisation of value chains, a number of relocations occur in sectors that are traditionally not associated with offshoring: professional activities (such as consultancy services), administrative and support service activities, information and communication. This finding can be explained to some extent by the CAM survey's broad definition of offshoring. Service offshoring has boomed since the early 2000s. Pisani & Ricart (2016) identify a total of 79 academic studies on service offshoring, published between 1990 and 2014. This type of offshoring can exhibit specific characteristics that differ from manufacturing offshoring. Doh *et al.* (2009) use US data to demonstrate that, contrary to expectations, a country is more likely to be a location to which services are offshored if the average wage in that country is high. The level of education and the similarities in culture between the countries of origin and destination are also key factors in any decision to offshore services

A very limited number of relocations have been recorded in sectors for which it would initially appear counter-intuitive: construction, trade, storage, and accommodation and food service activities. While a risk of error in the model's prediction cannot be ruled out, it is worth noting that 1% of the companies reporting to have offshored between 2009 and 2011 in the CAM survey belong to the construction sector and 16% fall under trade, storage or accommodation and food service activities. These cases can be explained by the survey's broad definition of offshoring, which incorporates certain cross-border economic effects in addition to changes in subcontractors (in favour of non-domestic producers).

Although we are unable to use the model to directly ascertain the countries to which activities are offshored, they can be deduced by observing trends in the offshoring companies' import flows. We will assume that the company has offshored its activities to the country in which its imports of specific goods have increased the most over the study period (maximum imports). Figure IX shows the significance of each geographical area in total predicted relocations over the study period, normalised by the value of recorded import flows.

A high proportion of relocations are to countries that border France: Germany, Belgium and Italy. By contrast, Eastern European countries account for a low proportion of offshoring – the fact that these countries joined the EU in 2004 or 2007 does not appear to have resulted in an increase in the rate of offshoring over the study period. Europe is the most popular offshoring destination for all periods: in 2018, more than half of all relocations were to Europe. Europe's dominance here is partly explained by the CAM survey's broad definition of offshoring, which likely includes cross-border economic effects. This finding thus provides context for the proportion of countries with low production costs within the offshoring data, particularly for manufacturing offshoring.

Relocations to Africa (including Northern Africa) are relatively minimal. There is a steadily increasing pattern of offshoring to the Middle East, Central Asia, South Asia and South-East Asia over the same period, with these regions accounting for almost a fifth of relocations, in terms of value, in 2018.

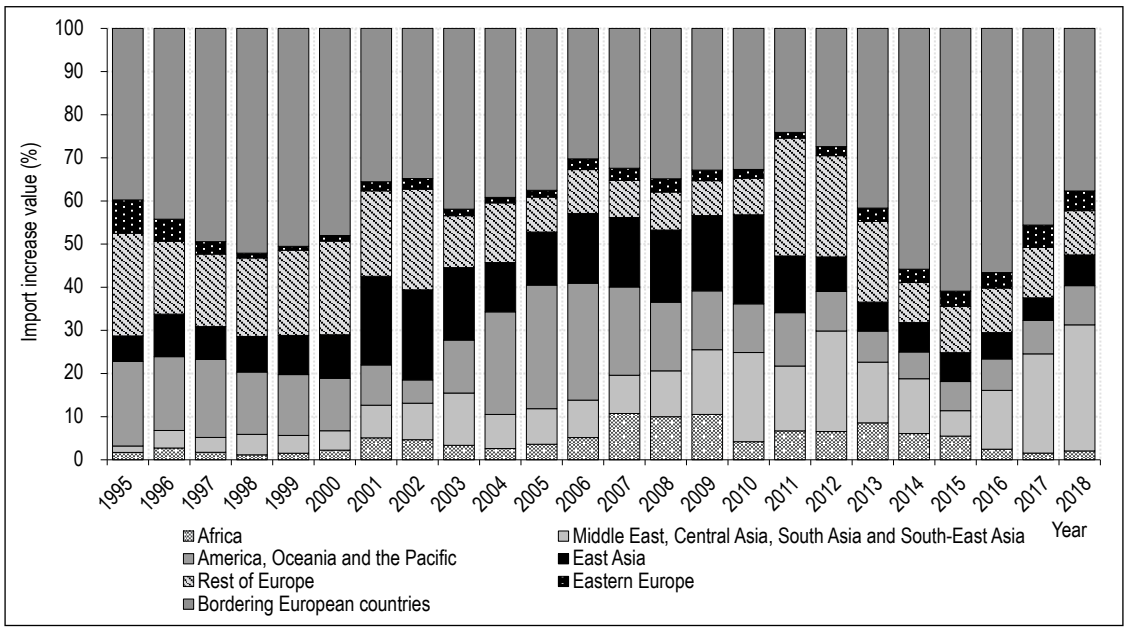
Pierce & Schott (2016) attribute much of US manufacturing's decline to the outsourcing of activities to China. Aubert & Sillard (2005) demonstrated that, between 1995 and 2001, China accounted for an average of 14.1% of manufacturing relocations, compared with 6.9% for the US. We observe similar values over this period when we widen the coverage. However, we see a downward trend for the proportions for East Asia (where China is dominant) and America (where the US is dominant), these regions accounting for only a fringe minority of relocations in 2018.

Figure X presents this information at individual country level (rather than aggregated geographical area level), aggregating all offshoring flows over the 1995–2018 period. The US and China rank among the top offshoring destinations over this period, but Germany and Belgium also feature.

4.2. Is Offshoring a Procyclical Phenomenon?

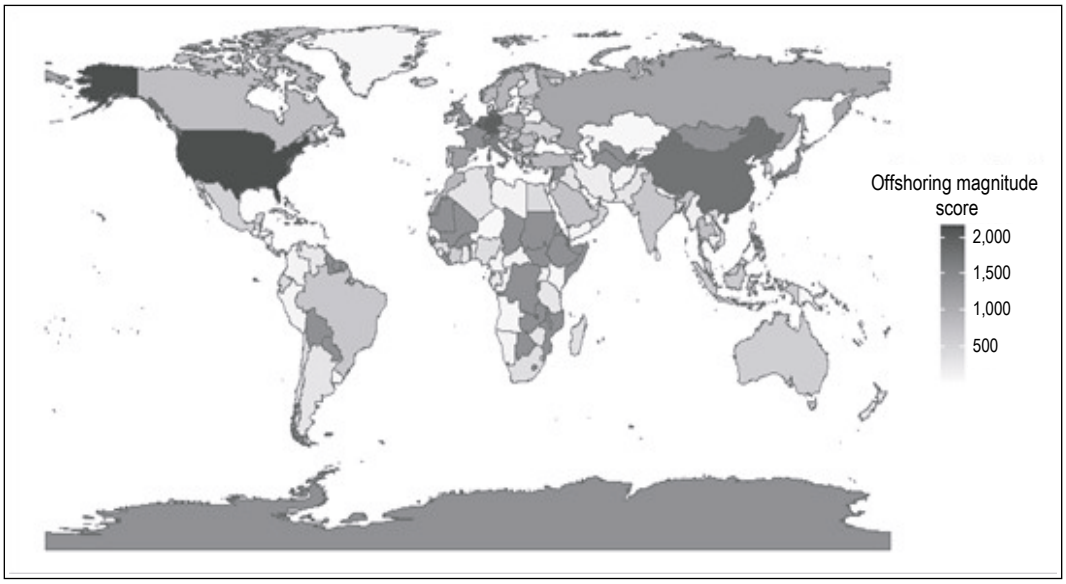
Offshoring (for which Figure VII shows the general trend) increases between 1998 and

Figure IX – **Breakdown of geographical areas from which maximum imports of specific goods increased for offshoring legal units (low scenario)**



Note: the categories are read from bottom to top for each year (from Africa at the bottom to bordering European countries at the top).
Source: INSEE, FARE and CAM – DGDDI, Customs.

Figure X – **Economic magnitude of offshoring (*via* maximum imports of specific goods) 1995–2018**



Source: INSEE, FARE and CAM – DGDDI, Customs.

2000 (strong growth years) and between 2006 and 2008 (strong GDP growth until Q3 2008). In contrast, periods of slowdown in GDP correlate with periods in which there are low levels of offshoring: 2002 and 2009–2010. These two factors therefore indicate offshoring's potentially procyclical nature.

Suggestions that offshoring may be procyclical are also raised in the literature. For example, Zlate (2016) shows that the output and value added of Mexican *maquiladoras* (plants in Mexico) correlate strongly with the US manufacturing cycle when observing the period between 1990 and 2007.

To test offshoring's procyclical nature, we compare the changes in offshoring (central scenario) with changes in the margin and investment rates (Figure XI). Over the 1995–2009 period, the correlation of our offshoring series is 0.70 with an investment rate of 0.70 and a

margin rate of 0.35, confirming the assumption that offshoring is procyclical over this period.

These correlations change in the aftermath of the crisis in 2008–2009: the investment rate picks up and the margin rate recovers, but offshoring stagnates. The correlations invert (−0.35 and −0.66, respectively), which indicates a change in company behaviour. There are several possible explanations for this, such as a sustained phase of debt reduction measures introduced by companies, thereby heightening their reluctance to invest abroad, or more intense price competitiveness within France over the period in question (wage moderation and competitiveness policies such as the CICE competitiveness and employment tax credit).

Offshoring requires the investment of substantial cash flows in a new "production mix", as defined by Schumpeter (1911). Building a new production site overseas requires time, funds and forward planning. These three elements are in short supply during a turning point in the cycle, a period that is also marked by radical uncertainty[14] when we observe the example of the 2008 crisis. A differing interpretation could be that companies tend to abandon native subcontractors and turn to subcontractors abroad during a crisis. This is what Chilimoniuk-Przezdziecka (2011) suggests. During economic booms, companies prefer internal restructuring measures to external ones (which include offshoring).

In the light of our findings, this behaviour is more than offset by the discontinuation of offshoring that requires a minimum level of investment. Furthermore, it is uncertain whether this subcontracting cost optimisation behaviour is amplified during a crisis: use of non-domestic subcontractors can be fully justified during

14. Knight (1921) introduces a distinction between risk, where the probability of each possible event can be measured, and uncertainty, where it is impossible to quantify probabilities in that same manner. Uncertainty is deemed to be radical whenever it is impossible to produce a list of possible events linked to a risk.

Figure XI – **Time-series comparison of offshoring, investment rate and margin rate**

Source: INSEE, FARE and CAM – DGDDI, Customs.

periods of strong economic performance, for the same cost-related reasons.

5. What Kind of Jobs Are Offshored?

5.1. Observing Job Losses Linked to Offshoring

Our evaluation at legal unit level,[15] following on from before, is a necessary yet inadequate step: necessary, because the CAM survey collects information at legal unit level, which means that the offshoring prediction models had to be designed starting from that level, and inadequate, because a number of large enterprises may have offshored only one of their establishments, or only a fraction of their activities. The aim of this section is to filter down to establishment and job level in order to quantify the number of jobs affected by offshoring with greater granularity (again drawing inspiration from Aubert & Sillard (2005)).

We rely on the *Déclarations annuelles de données sociales* (DADS – Annual Declarations of Social Data) for this purpose. With this database, it is possible to identify all establishments and positions[16] that form each legal unit recognised by our model as having offshored its activities. For all establishments affected, and drawing inspiration from Aubert & Sillard (2005), we presume that an establishment has been offshored if:

- the establishment existed in t but no longer exists in t+2;

- the establishment has lost more than 25% of its jobs, measured in full-time equivalents (FTEs),[17] between t and t+2 (threshold applied by Aubert & Sillard (2005) as it was below one standard deviation of the mean variation in employment).

We identify these establishments while considering any changes in SIREN numbers and the phenomenon of "economic continuity" (whereby an establishment and its workforce are taken over by another legal unit, as defined by Picart (2008)).

All jobs for establishments that disappear are deemed to have been offshored. For establishments that have lost more than 25% of their FTEs,[18] each of the jobs existing in t is deemed to be x% offshored (where x is the percentage of jobs eliminated between t and $t+2$). x therefore carries a weighting function. This method ensures that the number of offshored jobs matches the number of jobs lost between t and t+2 exactly (rather than using a calculation based on jobs not found in $t+2$, since jobs could well have been replaced in the intervening period).

Figure XII shows the change in the number of jobs eliminated as a result of offshoring between

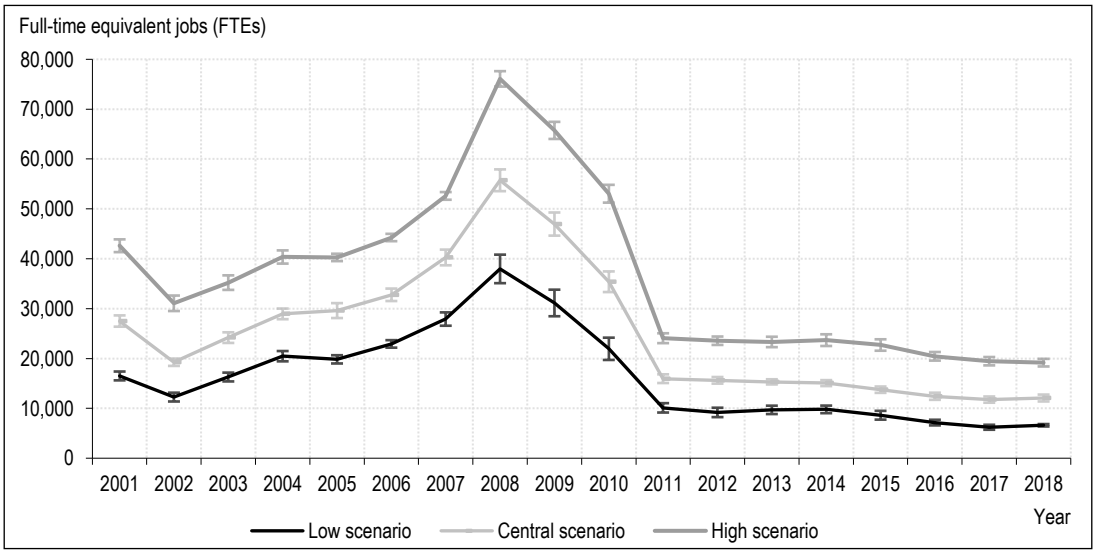
15. A legal unit is a legal entity under public or private law. This entity is identified by a SIREN number. Establishments are identified by a SIRET number and are production units that are geographically distinct yet legally subordinate to their legal unit. A legal unit may include multiple establishments.

16. The DADS database enables us to draw a distinction between "ancillary" and "non-ancillary" positions; we have included only the latter in this article. Non-ancillary positions are positions for which a defined annual threshold for remuneration and work duration is exceeded.

17. Here, we calculate FTEs in the standard way, in the DADS, omitting positions classed as ancillary and temporary work.

18. In reality, the number of offshored jobs is relatively insensitive to the 25% threshold: most establishments identified as offshored lost their entire workforce.

Figure XII – **Number of jobs predicted to have been offshored**



Source: INSEE, FARE and CAM – DGDDI, Customs.

2001 and 2018 in our three scenarios.[19] In the central scenario, offshored employment has been trending downwards over the last decade: while the average number of jobs eliminated each year between 2001 and 2018 was 25,000, only 12,000 jobs were eliminated in 2018. However, this figure disregards any jobs that may have been created at the same time and does not consider that people whose jobs have been offshored may find another job. Furthermore, this figure reflects only job losses in the company affected (and not jobs that have been lost at the company's suppliers, customers or subcontractors).

In the manufacturing sector, Aubert & Sillard (2005) identified an annual average of 13,600 jobs offshored between 1995 and 2001 (and as many as 19,400 by adjusting their model's parameters). Our results are of a similar scale, albeit with a slightly more comprehensive coverage.

5.2. Using Propensity Score Matching to Estimate Causal Job Losses

The advantage of the previous method lies in its ability to identify specific positions that have been offshored (see Section 5.3. for a study of their characteristics). Nevertheless, it does have two inherent risks of bias. First is a risk of overestimation, because the method ascribes all job losses observed over the period to offshoring, which is not necessarily the case for all of them. Second is a risk of underestimation, because the number of *ex post* jobs may have started to increase again as a result of offshoring during the period in question.

Another initial way to estimate the number of jobs offshored is to use another CAM survey question, which asks employers reporting activity offshoring to indicate the number of positions they believe they have offshored.[20] This approach is what leads Fontagné & d'Isanto (2013) to conclude that approximately 20,000 jobs in France were offshored over the three-year period 2009–2011, but they caution against overinterpreting this finding on the basis of the information reported. This translates to an average of 20.1 jobs eliminated per offshoring company.

There is a second different way to estimate the number of jobs offshored, which consists of adopting a causal econometric evaluation framework, drawing inspiration from Hijzen *et al.* (2011). Using a double-difference method, these authors compare companies that have made foreign investments with comparable companies (identified using a matching method) that have not. One of the challenges here lies in finding companies that can be considered "comparable". However, the CAM survey makes it possible to identify not only companies that have offshored activities, but also those that have only considered doing so. When asked about possible offshoring between 2009 and 2011, 4.2% of companies (weighted data) answered "yes", 3.1% answered "no, but it had been considered" and 92.7% answered "no, and it had not been considered".

Our identification strategy is therefore to compare companies that have offshored activities with those that have considered offshoring activities but did not follow through with it. Some of the unobserved characteristics are therefore controlled (a previous desire to offshore activities).[21] Once these unobserved characteristics have been controlled, the act of having offshored activities remains correlated with observed structural characteristics (business sector, size) and with other, more context-specific, characteristics associated with the perception of the barriers to be overcome in order to offshore activities[22] (information available in the CAM survey).

To aid comparability of the two samples – companies that have offshored activities and companies that have considered doing so – we carry out matching based on the propensity score. Several matching methods will be examined to check the robustness of results. In the six methods proposed, we match companies that share the same structural characteristics and/or consider three barriers to be of equal importance

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19. There are several potential breaks in the series, which render studying the changes in the curve more complex:
- In 2008: transition from FICUS to FARE. We previously noticed accounting approximations for a number of variables (such as financial investment). Additional transition from Naf_rev1 to Naf_rev2 (more detailed, particularly for customs data): imports of specific goods were identified less effectively (overestimation, because all potential Naf_rev2 codes are retained);
- In 2003: transition from Naf 1993 nomenclature to Naf_rev1 (same concern for approximation in the activity/product codes, although the change is less significant);
- In 2001: change in the way FTEs are calculated in the DADS. Approximation of the employee identifier in the DADS: continuity of activity is less readily identified, and fewer jobs are counted per establishment (the two effects act at cross purposes). This major break is a good reason for not observing data prior to 2001 in our retrospective estimates.
20. The question concerns the number of positions and not the number of FTEs.
21. Unobserved factors persist to some extent (for example, the macroeconomic or regulatory environment of the country being considered as an offshoring destination, which can influence the ultimate ability to offshore activities or not).
22. Fourteen different barriers are listed in question 2.10 of the CAM survey questionnaire. We will focus on three of these barriers, because they have a significantly different impact on offshoring companies compared with companies that are considering offshoring but have not followed through: the"risk of patent infringements and/or non-compliance with intellectual property rights", the "need to be in close contact with existing clients", and the "considerable general difficulties in view of the expected gains". Companies that ultimately did not offshore activities are therefore more likely to answer that they had faced these constraints than those that did: this is why these variables are included in the propensity score calculation.

in their offshoring plan (see Footnote 21). This strictly corrects for sector and size-related mismatches (over-representation of manufacturing companies and LEs or ISEs among offshoring companies) as well as mismatches linked to differing perceptions of the barriers to offshoring. Table 6 shows the cumulative gains in standardised proportional differences between initial and matched samples for these different matching methods (the higher the gain, the greater the similarity of the samples compared *ex post* with regard to the controlled characteristics).

The unmatched double-difference estimate forecasts an average loss of 38 jobs per relocation. The over-representation of large enterprises and manufacturing companies among companies that have offshored activities is therefore uncontrolled. However, like manufacturing companies, large enterprises tend to experience sharper falls in employment over the period. Whichever method is selected, matching leads to a more conservative estimate of job losses per relocation. The more precise the match with respect to the control variables, the more this estimate decreases: an exact match results in an average loss of 16 jobs per relocation.

The selection of the method to be used is the result of a trade-off between internal and external validities. The more precise the match, the greater the internal validity of the estimate. However, the more precise the match, the more likely it is that the counterfactual sample will consist of the same companies, drawn multiple times, which exposes the sample to a risk of overfitting.

Depending on the trade-off required between internal and external validities, a range of values can be calculated for the average job losses per offshoring company (between 16 for exact matching and 34 for 1:3 matching with replacement). This range makes it possible to validate the methodology specified in Section 5.1 on the basis of results. This methodology estimates the average job losses per relocation to be 29 (value within the range).

By comparing this range with the number of companies predicted to be offshoring their activities in Section 4.1, the number of jobs offshored in 2018 would be between 11,000 and 23,000, depending on the matching method used (12,000 jobs were predicted based on the DADS). Figure XIII shows the different possible series of offshored jobs, according to the method selected.

5.3. Offshored Jobs: Victims Over-represented Among the Most Stable

In addition to estimating the number of jobs affected by offshoring, precisely identifying affected jobs *via* the DADS (see the method described in Section 5.1) means that their characteristics and locations can be studied.

The French departments most exposed to offshoring are those with major cities – not least because they have the highest proportions of manufacturing jobs (Figure XIV). Offshoring due to cross-border economic reasons is evident in the French border departments to the north and east of the country.

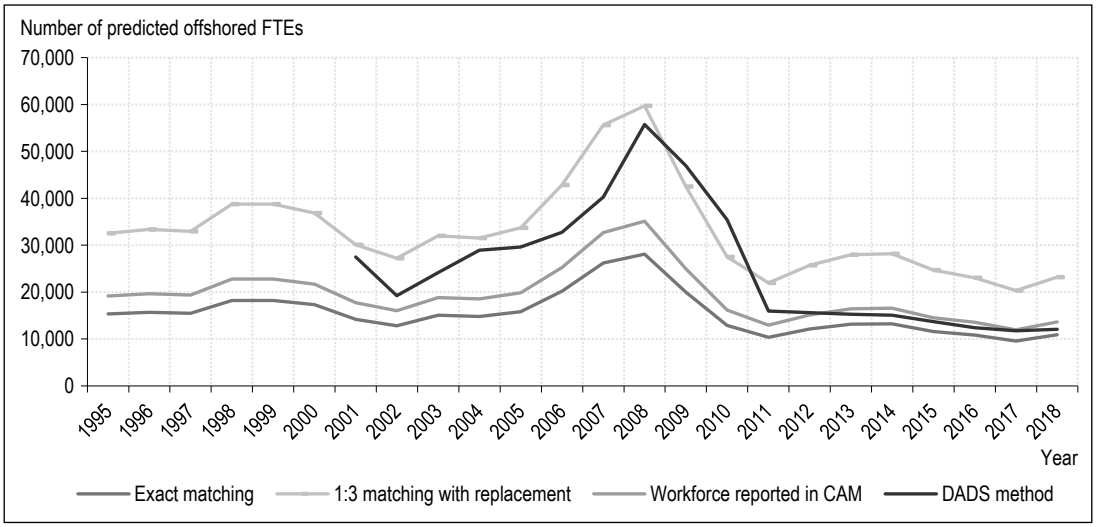
Stable jobs are slightly over-represented among offshored jobs (Table 7). Permanent contracts apply to 91% of offshored jobs, compared with 87% when we consider general coverage (i.e., CAM survey coverage). Full-time employment is also slightly more likely to be offshored (92%, compared with 87% for the general population). Engineers and technical company managers

Table 6 – **Comparison of different methods for estimating job losses associated with offshoring**

Method	Estimated average job losses per offshoring legal unit (ATT)	Cumulative gains in standardised proportional differences (matching quality)
1:1 matching without replacement (double differences)	−27 ***	< 0
1:1 matching with replacement (double differences)	−25 ***	+26
1:2 matching with replacement (double differences)	−29 ***	+28
1:3 matching with replacement (double differences)	−34 ***	+29
Exact matching on size and sector (double differences)	−24 ***	+35
Integral exact matching (double differences)	−16 *	+41
Double differences without matching	−38 ***	/
Reported response in CAM (number of offshored positions)	−20	/
Estimation *via* the DADS (see Section 5.1)	−29	/

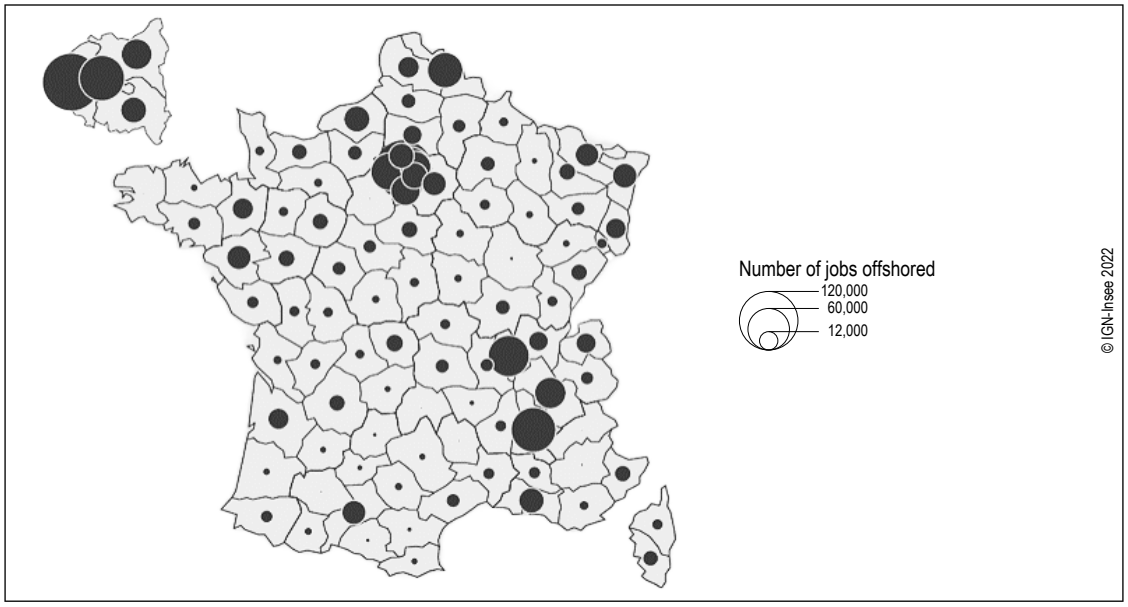
Note: 1:N matching signifies that *N* legal units in the control sample (legal units that have not offshored activities but have expressed a desire to do so) are drawn for each legal unit in the processing sample (legal units that have offshored activities).

Figure XIII – **Number of jobs predicted to be offshored by estimation method**



Source: INSEE, FARE and CAM – DGDDI, Customs.

Figure XIV – **Distribution of positions eliminated as a result of offshoring, by French department**



Source : INSEE, FARE and CAM – DGDDI, Customs.

are slightly over-represented among offshored jobs (13%, compared with 10% for the general population) and the same is true of skilled manufacturing workers (19%, compared with 13% for the general population). These over-representations are explained to some extent by the highly manufacturing nature of relocations and the characteristics of the companies that decide to offshore their production.

* *
*

Offshoring continues to be an economic phenomenon that is shaping the evolution of manufacturing employment in France. While offshoring appears to have declined since the 2009 crisis (down 25% between the periods of 1995–2005 and 2010–2018), the reindustrialisation observed in 2017–2018 has not halted the rate of relocations. Offshoring is touted as a major and ever-present problem in public discussions and its quantification is a major academic challenge.

We propose a new methodology for quantifying relocations in this article, inspired by the current literature. Data from INSEE's CAM survey makes it possible to identify actual offshoring at the turn of the 2010s. This data is combined

Table 7 – **Characteristics of employees who have lost a job due to offshoring (%)**

Variables	Categories	General coverage	Offshored positions
Occupation category	37 – Business and administration professionals	8	9
	38 – Engineers and technical company professionals	10	13
	46 – Administration and business associated professionals	8	9
	47 – Technicians	7	10
	48 – Supervisors, overseers	4	4
	54 – Corporate administrative clerks	9	8
	55 – Sales employees	8	4
	56 – Personal services employees	2	1
	62 – Skilled manufacturing workers	13	19
	63 – Skilled artisanal workers	4	2
	64 – Drivers	5	2
	65 – Skilled workers in maintenance, storage and transport	4	3
	67 – Less skilled manufacturing workers	6	9
	68 – Less skilled artisanal workers	4	1
	Other category	9	10
Age group	Aged 0–25	11	7
	Aged 26–35	28	26
	Aged 36–45	29	30
	Aged 46–55	24	29
	Aged 56 and over	8	8
Status	Full-time	87	92
	Part-time	13	8
Employment contract	Permanent	86	91
	Temporary	7	5
	Other type of contract	6	5
Gender	Male	67	67
	Female	33	33

Note: Skilled manufacturing workers account for 19% of offshored positions, compared with 13% of positions in the general coverage.
Source: INSEE, FARE and CAM – DGDDI, Customs.

with customs and tax data to construct models to predict offshoring. Estimating these models enables us to estimate the number of companies that have offshored their activities each year over the 2001–2018 period, the scale of which confirms the findings in the literature.

Offshoring's impact on the decline in manufacturing employment is certainly less quantitative than qualitative, which is also why it merits inclusion on the political agenda. The baseline figure of 10,000 jobs offshored each year must be assessed in connection with the number of manufacturing jobs – and any comparison cannot afford to ignore the relevant counterfactual (would the companies have gone bankrupt without any relocations whatsoever?). Qualitative impact can be assessed by studying the characteristics of employees whose jobs have been relocated: the most stable are generally affected. Offshoring therefore plays a role in the "destabilisation of the stable" movement described by Castel (2013). Given that relocations primarily occur in the manufacturing sector, they undermine a certain archetype of salaried manufacturing employment: workers more likely to be on a permanent contract, more likely to be working on a full-time basis, and more likely to be skilled.

The various external validity tests (in which our results are compared against the Trendeo or CAM-PME databases) suggest that we should be wary of too hastily making sweeping generalisations based on the results, especially in connection with SMEs covered in our study (SMEs with more than 50 employees). Limiting the data we use to a single year of the CAM survey runs the risk of overfitting the model to the macroeconomic conditions of 2009–2011: matching these conditions too precisely could result in the analysis failing to adapt to data taken from other years. Future versions of the CAM survey, which are scheduled for completion every three years starting in 2020, will make it possible to calibrate our offshoring prediction models with greater accuracy and relevance.

The construction of long offshoring data series remains an interesting support tool for making

decisions. Although this does not enable us to make very short-term predictions about changes in offshoring (as FARE database accounting information is made available several years after the period to which it relates), it does enable us to evaluate policies aimed at boosting competitiveness on an *ex post* basis. Long series also enable microeconomic and macroeconomic determining factors behind offshoring to be examined in greater depth. □

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Public Aid and the Performance of Born Globals

Flora Bellone*, Catherine Laffineur and Sophie Pommet****

Abstract – Analyses of born-global firms have not yet provided a comprehensive picture of the role of public aid in supporting those firms that specifically seek to internationalize early and intensively. To fill this gap, this paper uses a unique dataset that combines comprehensive information about both the production and export activities of newly established French manufacturing firms and a variety of public support instruments allocated to those firms by Bpifrance, the French public investment bank. Our key result is that French born globals are less likely than their more traditional exporting counterparts to receive public aid dedicated to generally support their investment projects. By contrast, they are as or more likely to receive public aids specifically dedicated to support their innovation and internationalization projects. We also show that the returns on aid dedicated to investment projects are especially high for born globals. We conclude that there is room to improve the allocative efficiency of public support towards born-global firms.

JEL: F14, G24, L25, M13
Keywords: born-global firms, public financial aids, firm-level data, export premia, subsidies, loans

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This study has been conducted as part of the "Entreprises à Internationalisation Rapide et Précoce 2020" project undertaken at GREDEG under a partnership agreement with Bpifrance le Lab. It uses micro-data from the "Census of Enterprises" and the "Financial linkages across companies" surveys, both conducted by INSEE (the FICUS-FARE and LIFI datasets), as well as firm-level transaction data collected by French customs, and firm-level information compiled by Bpifrance (the French public investment bank). These diverse data sources were accessed through the Centre d'Accès Sécurisé aux Données (CASD), a public research infrastructure developed under the Programme Investissements d'Avenir n° ANR-10-EQPX-17.

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In most developed countries, the performance of manufacturing firms in export markets has become a major concern for policy makers. This concern meets the widely acknowledged view that it is mainly small and young innovative companies that create the most wealth and jobs in the long run. Policy makers now acknowledge that at least some newly established businesses are born globals in the sense that they internationalize very early, if not at birth, and make a large share of their turnover in export markets from the very beginning of their existence. However, in most industrialized countries, born globals still represent a small percentage of all start-ups. A policy issue is then whether more start-ups should be encouraged to engage in such born-global strategies and/or be offered specific support schemes to help them fully exploit their innovative and economic potential.

In the literature, the relationship between public support and born-global strategies is seldom addressed, even if the issue of international entrepreneurship has a long tradition, which can be traced back to the early contributions by Cavusgil (1980), McDougall (1989), Oviatt & McDougall (1994), Knight & Cavusgil (1996), and Madsen & Servais (1997), among others. In a seminal survey, Cavusgil & Knight (2015) acknowledge the lack of policy-oriented studies in this field. This means that current public and policy discussions have largely rested on limited evidence based on case studies rather than on systematic evidence based on survey analyses or on large-scale longitudinal firm-level data. Moreover, none of the few recent studies that provide systematic quantitative evidence on the relative characteristics of born globals, as Choquette *et al.* (2017) for Denmark, Braunerhjelm & Halldin (2019) and Ferguson *et al.* (2021) for Sweden, directly address the issue of public policies.

In this paper, we fill this gap by investigating the relationship between public aid and the performance of born globals in the case of France. More specifically, we analyse the relationship between key characteristics and relative performances of French born globals and their likelihood of obtaining two specific types of public funds, namely subsidies and public loans. For this, we use an exhaustive dataset of French manufacturing firms that covers the period 1998-2015. This dataset, unique in France, has two main advantages compared to those used in earlier literature. First, it provides extremely rich and detailed information on the production and export activities of a large subset of French manufacturing companies, thus enabling fine-grained measures of firm performance. Second, this information can be matched with exhaustive information on public financial aid, specifically innovation subsidies, and innovation, internationalization and investment loans, granted to these newly established manufacturers.

This enables us to examine, for the first time for France, the extent to which born globals differ from other exporters in their reliance on public support. Because born globals seek fast and early internationalization, they might have larger needs of external funding due to their limited tangible resources. On the other hand, because they are by nature less able to offer domestic collaterals than firms which first established themselves locally before expanding abroad, they might also be the least apt to access external funding.

Our key results are as follows. The born-global status of a firm is positively related to its participation in some supportive programs offered by the French public investment bank such as innovation subsidies and international loans, but negatively related to its participation in other programmes such as investment loans. A rationalization of the aid system in favor of born globals could then be desirable. First, while we find a positive effect of investment and international loans on the turnover of born globals, we do not observe any statistically significant effect of innovation loans and subsidies on recipients' firms up to 5 years after being granted. Second, the born-global performance advantages are correlated with the exports scope but not with the average quality of their exports. As a result, born globals might be more in need of public funding supporting their market expansion, which is the case for international and investment loans more than for innovation subsidies and loans.

The rest of the paper is organized as follows. Section 1 reviews the relevant literature and how we build on it. Section 2 describes the data and provides some descriptive statistics about the born-global phenomenon in France. Section 3 lays out our econometric analysis and discusses the results, before some concluding remarks.

1. Literature Review

Our study relates to three main branches of the literature. The first branch explores firm heterogeneity in international trade. The second one investigates the born-global strategy. The third one focuses on policy actions aimed at supporting the internationalization of small and

medium-sized enterprises (SMEs), especially young ones. In this section, we provide some of the theoretical and empirical background behind each branch of the literature and explain how our study builds on their interconnection.

1.1. Firm Selection and Export Premia

In the late 1990s, a literature emerged, and has dramatically expanded since, dedicated to exploring the export and productivity nexus at the firm level (see the seminal contributions of Bernard & Jensen, 1995; 1999). The existence of large export premia has been established for various performance indexes, primarily turnover, employment, wages, productivity and profitability (see ISGEP (2008) for cross-country comparative evidence, and Bellone *et al.* (2008) for detailed evidence from France). This literature further showed that the productive advantage of exporters over their non-exporting counterparts is usually observed *ex ante*, i.e. before their entry into export markets, supporting the theory that heterogeneous firms make different choices in terms of export strategy (Melitz, 2003; Bernard *et al.*, 2003). This mechanism is known in the literature as self-selection into export markets as it entails that only firms productive enough to support the additional costs of exporting can afford to expand their activity abroad.[1]

In the late 2000s and early 2010s, a second wave of this literature mobilized richer datasets to provide a better account of the variety of firms' export strategies and of their relationship to firm performance. From these works, some further consensual findings emerged. First, the degree of internationalization is positively related to firm performance; in particular, firms that export earlier, more intensively, and with more products towards more destinations exhibit the highest export premia (Crozet *et al.*, 2011). Second, productive efficiency is not the only determinant of export participation: specific managerial assets such as previous international experience and social and networking capital, as well as specific demand shocks, also play a large part in explaining the diversity of the internationalization path of firms (Albornoz *et al.*, 2012; Aw *et al.*, 2019).

Overall, the literature on export premia leads us to expect that the born-global strategy could indeed be an attribute of start-up firms exhibiting high-performance. For instance, those firms could own specific innovative assets that make them more able to scale their production to the global level. They could also possess previous international expertise, specific international managerial ability, or some higher productive efficiency, each of which could allow them to overcome more easily barriers to export. In our research, we provide new evidence to support these hypotheses, and we extend the literature on export premia to the unchartered territory of the relationship between export premia and public support to firms.

1.2. The Born Global Strategy in Detail

Qualitative research on born globals has expanded rapidly over the last decades, focusing on documenting their characteristics and understanding the underlying trends that give rise to these types of firms (Moen & Servais, 2002). Among other results, these studies have found that born globals are typically innovation intensive (Andersson & Wictor, 2003; Knight & Cavusgil, 2004) and human capital intensive (McDougall *et al.*, 1994, 2003; Knight, 2001; Melén & Nordman, 2009; Del Sarto *et al.*, 2021) and are characterized by a production process that is easily scalable (Kudina *et al.*, 2008; Cannone & Ughetto, 2014).

Although the literature on born globals has expanded, little systematic evidence on the extent or consequences of early internationalization based on comprehensive datasets of firms exists (Dabić *et al.,* 2020). Notable exceptions are the recent papers by Choquette *et al.* (2017), Braunerhjelm & Halldin (2019) and Ferguson *et al.* (2021), which provide the first systematic analyses of the relative performance of born globals for Denmark and Sweden. However, a puzzling finding of these first quantitative papers is that born globals are not that different from their counterparts who enter the export markets more gradually. For instance, Ferguson *et al.* (2021, p.12) conclude as follows: "*The evidence presented here suggests that there is no clear advantage in terms of long-run employment, turnover or value-added associated with a born-global strategy.*"

Our study builds on these premises and contributes to reducing the lack of reliable large-scale firm-level evidence on the born-global phenomenon. First, we investigate whether our data on France support the finding of unexceptional performance of born globals or whether they provide more support to the theoretical predictions that born globals should outperform

1. The literature also provides some supportive evidence for the existence of learning-by-exporting effects, implying an opposite causality that runs from export to productivity (De Loecker, 2013). However, this finding is less pervasive across countries, industries, and firms, and more sensitive to methodological choices.

their counterparts who export more gradually. Second, we push the analysis of the distinctive features of the born-global strategy further by emphasizing the scope and the quality of firm export portfolios. Third, we investigate whether born globals display any distinguishable quantitative features in the way they benefit from public support. In doing so, we shed new light on recent policy-oriented issues that we now briefly review.

1.3. Public Support in Question

The case for public action in favour of the international activities of firms is all but obvious. Contrary to the case for public support to innovation, which reached a kind of consensus among academics and practitioners in the 2000s (Aghion *et al.*, 2009), such a consensus does not yet exist for actions specifically dedicated to sustaining the export strategies of firms. For example, the literature on export premia has mixed policy implications. On the one hand, by emphasizing self-selection mechanisms, this literature has been prone to conclude that policies aimed at promoting the entry of firms into export markets are likely to be a waste of resources (Greenaway & Kneller, 2007). On the other hand, by revealing the existence of credit market imperfections that act as a barrier to export participation, some further papers have advocated in favour of policy actions aimed at promoting the export participation of financially constrained firms (Máñez *et al.*, 2014).

Whether public policy should directly support the internationalization of SMEs has also been extensively debated in the business-oriented literature (Acs *et al.*, 1997). No large consensus emerged on this issue, although many claimed, in the 2000s and 2010s, the need to provide born globals with adequate public support. For instance, Wright *et al.* (2007) claim that appropriate policy schemes must be designed differently at different points on the spectrum of firms, which can range from those that do not and cannot internationalize to those that internationalize from their inception. In the same vein, the policy reports by Eurofound (2012) and the OECD (2013; 2018) also emphasize that policy schemes designed to support SMEs' traditional modes of gradual internationalization might not be effective, or even be counterproductive, when the target is other types of exporters such as born globals. For instance, Eurofound (2012) notes that public support measures to foster start-ups often include eligibility criteria which hinder born globals' access to the instrument. This might be, for example, the requirement to have an established home market or a well-tested product or service before qualifying for financial support for internationalization or the implicit necessity to have sufficient financial resources to cover costs, as reimbursements will be provided only later on. On the other hand, the OECD (2013) emphasizes that only a few OECD countries have policy support programmes specifically dedicated to born globals and makes the basic claim that those specific programmes should be more widespread across OECD countries.

Beyond those specific policy schemes, the international entrepreneurship literature also emphasizes the complementary role of other policy measures dedicated to support the general investment activities of born globals (Cavusgil & Knight, 2015; Sui & Baum, 2014). A key argument here is that born globals usually expand rapidly in external markets because they exploit specific intangible assets. As young and innovative firms usually face stronger financial constraints than other firms (see, among others, Meuleman & De Maeseneire, 2012), it is likely that born globals also face stronger financial constraints than other newly established firms that follow more traditional internationalization paths. Indeed, born globals are known to lack domestic collateral, as they earn a large share of their revenues in foreign markets early in their life. In this context, one might wonder whether policy actions aimed at easing the financial constraints that bear on innovative firms benefit born globals especially.

Considering specifically the French case, public support for young and innovative firms can be traced back to the late 1960's with the creation of the Agence nationale de valorisation de la recherche (a public agency dedicated to the industrial valorisation of research and aid for innovation, created in 1967, which after various reorganisations is now part of Bpifrance – see below). However, in the late 2000s, the innovation dynamics in France were still considered too weak (OECD, 2014), with firms that were willing to innovate declaring a lack of external and internal funds and the cost of innovation as their primary obstacles. In this context, in the end of 2012, the French government created Bpifrance[2] as a one-stop shop to better allocate public support to French firms. Bpifrance uses different types of instruments, from subsidies to loans, and provides support not only for innovation projects but also for internationalization

2. Bpifrance was created as a merger of three pre-existing public institutions dedicated to business-oriented policy actions in France: OSEO, CDC Entreprises and the Fonds Stratégique d'Investissement *(FSI).*

and investment projects.[3] Born globals, like any other firm in France, are eligible for this support conditional on some criteria for size, age and financial health that vary according to the instrument. However, none of these instruments is specifically designed to target born globals.

Considering the likelihood of benefiting from public support, Huergo & Moreno (2017) show that firm characteristics impact the likelihood of Spanish firms participating in various R&D support programmes and that this impact varies across the types of tool and, in particular, between loans and subsidies. Interestingly, they show that the export status of the firm is positively linked to the likelihood of benefiting from a European R&D support programme but not from a national subsidy. Our paper adds to this line of research by investigating the extent to which the born-global status of a firm is related to its participation in various types of supportive programmes offered by Bpifrance.

2. Data, Definition of Key Variables, and Descriptive Statistics

2.1. Data Source

We use three main sources of micro-level data. First, we rely on data collected by the French national statistical office, INSEE, namely the FICUS-FARE database and the LIFI database. The FICUS-FARE database covers the universe of French firms under the BRN and RSI tax regimes and, since 2008, the micro-BIC regime.[4] It includes key firm accounting information such as turnover, value-added and number of employees. The LIFI database is built from a survey and allows us to complement firm-level information with additional information on the ownership structure of the firm. Specifically, we can identify whether the firm is an independent business or a subsidiary within a domestic or foreign group.[5]

Second, we rely on detailed firm-level data on exports derived from French Customs records. These additional data allow us to identify both the product exported by the firm and the destinations that the firm serves. Destinations are defined at the country level and correspond to the final destination of each export flow recorded by the Customs Office, and products can be differentiated up to the 10-digit product classification code, although in this research, we use more aggregated NC product classifications to compute our product scope and product quality indexes.[6]

Finally, we merge the INSEE and Customs firm-level data with detailed firm-level data on public aid from Bpifrance records. This unique data source provides us with exhaustive information on the type, amount and timing of the public aid that Bpifrance (itself or the previous public institutions) offered to French firms over our period of observation. The information provided in the Bpifrance database allows us to distinguish among various instruments that differ either in terms of type (loans *versus* subsidies), or in terms of the activity targeted (investment, internationalization, or innovation).

More precisely, *"investment loans"* aim at financing investment in intangible assets that firms need to develop their activity in general. Such loans can cover expenses related to product upgrading, or environmental protection, external growth, recruitment and training of the sales team, development works, prospecting, advertising, acquiring materials, developing software packages, purchasing equipment with low resale value, maintaining working capital requirements, etc. *"International loans"* are specifically dedicated to support external growth in foreign markets. Such loans can be used to finance the increase in working capital generated by an internationalization project, investment in intangible assets, or investment in tangible assets with low pledge value. Finally, *"innovation loans*" are dedicated to supporting the development of new and innovative products, services or processes by firms. Because they are loans, each of the above three financial supports are allocated according to traditional bank criteria related to the firm's capacity to make monthly payments, although these criteria might differ slightly from one instrument to another.[7]

The two last instruments we consider in our study are of the subsidy type. First, Bpifrance grants

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3. More detail on the different instruments and their eligibility criteria is given in the data section below.

*4. The "BRN" (*Bénéfice Réel Normal*) and "RSI" (*Régime Simplifié d'Imposition*) are the two main tax regimes for all types of for-profit businesses in France. The "micro-BIC" regime is a simplified regime applicable to very small firms whose total sales do not exceed 170k euros if the firm operates within the real estate and trade sectors, or 70k euros otherwise.*

5. Contrary to the FICUS-FARE database, the LIFI database is not exhaustive, as only French companies in the private sector with a portfolio of equity securities greater than €1.2 million euros, with a turnover greater than 60 million euros, or with a salaried workforce greater than 500 people, regardless of the sector of activity, are surveyed (in addition to all the heads of groups from the previous year and the companies directly owned by a foreign company). Consequently, if some firms are owned by French companies below the abovementioned thresholds, they will appear as independent instead of affiliated in our sample.

6. Specifically, we compute our scope variable at the 6-digit product classification level as in Choquette et al. *(2017) and the quality variable at the 8-digit product classification level to follow Manova & Yu (2017), our benchmark methodology paper for this index.*

7. We do not have access to the selection criteria used by Bpifrance to determine the allocation of each type of loan. What we do know is that eligibility criteria are very similar. For all types of loans, any SME and ETI is eligible on the condition that the firm is independent or is less than 25% owned.

"*repayable advances*" to support innovation projects in their development stage.[8] Specifically, repayable advances aim to finance the production and development of prototypes, pre-series, pilot or demonstration installations, intellectual property expenses, standards upgrades, designs and market test studies. Second, Bpifrance grants "*pure innovation subsidies"* to support innovative projects at an early stage. These subsidies can be used to finance evaluations of the feasibility of an innovation project, the establishment of technological partnerships, and R&D expenditures.

2.2. Sample Construction

To build our sample, we merge the three datasets mentioned above over the longest common time coverage, i.e. 1998-2015, and then restrict our dataset to firms that declare a main activity code within the range of manufacturing activities (NACE Rev. 2 industries 10−33) at their date of entry[9] and a birth date within the range of 1998 and 2010.[10] Overall, this raw sample consists of 317,095 firms. The average firm in this sample employs 7.2 people and generates turnover of approximately 1,583k euros (see Table A1 in the Appendix).

As any other large dataset on firms, ours is noisy and includes values that we consider highly dubious. To avoid our results to be driven by those inconsistent values, we drop observations with negative or null turnover and employment and strictly negative value added and assets, as well as export intensity (defined as the ratio of firm total export values to firm total sales) greater than 1. After this cleaning, our remaining sample consists of 101,470 firms, employing on average 18 people and generating a turnover of approximately 3,524k euros. The main driver of the increase in the average firm size of this sample as compared to the raw sample is the exclusion of firms with zero employees or turnover.

On this cleaned sample, we perform two more selections. First, for both comparability and conservative purposes, we remove firms that report employment and turnover values at inception in the top 1% of the corresponding distribution. For comparability purpose, this is similar to the selections made by Choquette *et al.* (2017) and Ferguson *et al.* (2021) which are our benchmark papers. For conservative purposes, it limits the risk of confusing spinoffs as new business entities.[11] After this first selection, we are left with a sample of 96,434 firms. In this sample, the average firm employs 7 people and generates a turnover of approximately 679k euros.

The second selection consists in removing firms that do not survive for at least six years, as observing firms in the first years of their existence is necessary to define our different firm status (see the next section). This results in a final sample of 244,061 observations for 24,399 firms. These firms on average employ 7.7 workers and generate a turnover of approximately 970k euros. We provide more detailed comparisons between our raw, cleaned, intermediary, and final samples in Table A1 of the Appendix. Those comparative statistics show that our final sample is quite representative of our raw sample despite a size and survival biases in favor of exporting firms as compared to non-exporting ones.[12]

2.3. Key Variables

2.3.1. Defining the Born-Global Status

One important challenge is building a definition of born-global firms that can be easily applied to large-scale datasets and can allow for fruitful analyses and cross-country comparisons. The most common definitions currently in use rely on both an arbitrary measure of early entry into exports and an arbitrary measure of high exposure to exports. The definition we use here is very close to the one initially introduced by Choquette *et al.* (2017).

Specifically, we define born globals as French firms that have an export intensity of at least 20% for at least one year in the first three years of their existence. Relatedly, we define *born exporters* as firms that export within three years after birth but have an export intensity less than 20% each year over that period and *late exporters* as firms that export in their fourth year after birth or later. Finally, *non exporters* are firms that never export over our period of observation. For each category, we build a corresponding dummy

8. Repayable advances are grants that the firm must repay to Bpifrance after (and only if) the innovation project is successful.
9. Our restriction to manufacturing firms is primarily due to data limitations, as service exports are not recorded in French customs transaction data. However, it also facilitates comparability, as the previous quantitative evidence provided by the literature focuses on manufacturing firms only.
10. We exclude firms that are highly inconsistent in the birth date they declare during the period of observation or that show too large a discrepancy between their self-declared birth date and their first year of observation in our dataset. Specifically, we drop firms with a gap larger than two years between the declared birth date and the first date of observation.
11. Being able to control for the firm ownership through the LIFI dataset is not enough to exclude this risk. Ferguson et al. *(2021) additionally take advantage of a unique feature of the Swedish dataset that allows for the precise identification of spinoffs, as it includes the percentage of the initial workforce which originated from a same former employer.*
12. In an additional Online Appendix, we further provide robustness checks of our key results by running our regressions on the alternative raw, cleaned, and intermediary samples.

variable that takes the value 1 if the firm fits in the category, 0 otherwise.[13]

2.3.2. Defining our Key Variables

We use three main variables to measure firm economic performance: *Employment*, measured as the number of full-time equivalent employees, *Turnover*, measured as the value of sales and *Labour productivity*, defined as the ratio of value-added to the total number of employees.

We capture the firm exporting strategy by the scope and the quality of the export portfolio of the firm. The export scope of firm *i* in year *t* is measured through two complementary variables: *Product scope*, proxied by the number of HS 6-digit different products exported,[14] and *Destination scope,* proxied by the number of foreign countries reached as final destinations by the exported products. The quality of the export portfolio is measured by a variable (*Product quality)* built following Manova & Yu (2017) as the difference between the producer's log price (unit value) for the HS 8-digit product category the firm is exporting and the average log price of the same product across all firms exporting it. For firms exporting several products, we measure overall product quality as the weighted average of the product quality for each HS 8-digit product across all products the firm is exporting, using the export values as weights.

Finally, to capture the public support granted by Bpifrance to firm *i* in year *t*, we construct 4 dummy variables that identify separately whether firm *i* has benefited in year *t* from an investment loan, an international loan, an innovation loan or an innovation subsidy. Note that the latter category pools together repayable advances and pure subsidies.

2.3.3. Control Variables

In our empirical analysis, we control for several firm characteristics that might influence economic performance independently of the firm's born-global status. Following the earlier literature on export premia, we use two additional controls: *Firm size,* computed as the sum of tangible and intangible assets (in thousands of euros), and *Firm ownership,* a qualitative variable taking 3 values depending on whether the firm is 1) identified in LIFI as owned by a French company, 2) identified in LIFI as owned by a Foreign company, or 3) residually considered as independent.

2.4. Descriptive Statistics

According to our data, born globals represent a low percentage of active manufacturing firms in France. As shown in Table 1, in our sample, non-exporting firms represent more than 80% of entering firms in all the observed entry cohorts except the last one. Over the entire period, born globals represent around 3% of newly created businesses. Added to the born exporters, early internationalizing firms represent around 12% of all firms that entered the French manufacturing sector over the period 1998-2010 and survive at least 6 years.

Table 1 also illustrates the general trend of decreasing firm dynamism in French manufacturing over our period of investigation. However, the born-global phenomenon has remained relatively stable over that period. At the exclusion of the exceptionally high value for 2010, the percentage of born globals stood around 2.8% of manufacturing companies created each year, a figure consistent although slightly below that observed in Sweden and Denmark, which was of 3 and 4% respectively (see Ferguson *et al.*, 2021, and Choquette *et al.* 2017, respectively).

From the earlier literature, we expect born-global firms to display distinct characteristics from non or less exporting ones.[15] Various export premia computation exercises comfort this expectation. Specifically, we show that born globals generate a higher turnover, employ more workers and are more productive than their counterparts that follow later or less intensive internationalization paths (Table 2).[16]

We further show that the better performances of born globals persist over time, although the

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13. We tested the robustness of our results to changes in the definition of born globals. First, we changed the criteria for the persistence of export behaviour over the first years of the firm's existence by imposing that our baseline export intensity threshold of 20% prevails on average over the three first years of activity instead of "at least once". This makes our definition closer to the one used by Ferguson et al. *(2021). Second, we made the lower bound on the export to turnover ratio a stricter bound (25%) and a weaker bound (15%). Finally, we changed the length of time after birth during which a firm must start exporting to be qualified as born global by making it shorter (2 years) or longer (4 years) than our baseline definition. All our results are robust to these changes of definitions.*

14. Two products are considered as different if they are not classified in the same item of the Harmonized Commodity Description and Coding System (HS) of UN COMTRADE at the 6-digit level. The HS is the standard classification of products for trade data.

15. In Table A2 of the Appendix, we provide summary statistics on our variables of interest across different categories of firms: born globals, born exporters, late exporters and non exporters. Those statistics show that the average values of the performance variables are systematically higher for born globals than for any other category of firms.

16. Counterparts means firms of similar size and ownership status, belonging to the same industry, born in the same cohort and observed in the same year. Note that our results are not all in line with the previous quantitative evidence on Danish and Swedish firms established with the same methodology. First, in contrast with Choquette et al. *(2017), who find no productivity premium for Danish born globals, we do observe such a premium in the French case. Second, contrary to what Ferguson* et al. *(2021) found for Swedish firms, we find that the born-global premia in France do not fade out after we control for firm ownership and are visible although we exclude firms with the top 1% of initial firm employment to limit the risk that we consider spinoff firms as new business entities.*

Table 1 – **Distribution of entrant firms by type and entry year**

Year of entry	No. of entrants	Born globals (%)	Born exporters (%)	Late exporters (%)	Non exporters (%)
1998	2,893	3.08	10.37	6.19	80.37
1999	2,755	3.12	9.76	5.95	81.16
2000	2,754	2.40	8.50	6.86	82.24
2001	2,628	3.23	8.75	5.71	82.31
2002	2,487	2.69	8.12	6.47	82.71
2003	2,281	2.59	7.76	6.66	82.99
2004	2,142	3.08	7.19	5.37	84.36
2005	1,769	2.26	8.59	6.44	82.70
2006	1,554	2.90	9.33	5.15	82.63
2007	1,324	2.72	7.10	4.00	86.18
2008	520	2.50	8.46	3.08	85.96
2009	909	3.85	10.01	2.97	83.17
2010	383	6.79	10.97	3.92	78.33
Total	24,399	3.17	8.84	5.29	82.70

Sample: Manufacturing firms born between 1998 and 2010 and surviving at least 6 years.

Table 2 – **Economic performance by exporter type**

	Turnover		Employment		Labour productivity	
	(1)	(2)	(3)	(4)	(5)	(6)
Born globals	1.551***	0.784***	0.742***	0.434***	0.146***	0.059**
	(0.046)	(0.049)	(0.035)	(0.037)	(0.021)	(0.023)
Born exporters	1.240***	0.463***	0.613***	0.285***	0.055***	−0.025*
	(0.027)	(0.034)	(0.020)	(0.025)	(0.011)	(0.015)
Late exporters	0.773***	*Ref.*	0.345***	*Ref.*	0.079***	*Ref.*
	(0.027)		(0.019)		(0.011)	
Non exporters	*Ref.*	-	-	-	-	-
Firm size (Assets)	86.30***	52.98***	68.90***	45.08***	16.80***	9.13***
	(20.29)	(12.75)	(16.18)	(11.24)	(3.387)	(2.192)
Independent firm	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*
French ownership	0.196***	0.216***	0.126***	0.139***	0.005	0.015
	(0.007)	(0.014)	(0.006)	(0.010)	(0.006)	(0.010)
Foreign ownership	0.474***	0.536***	0.241***	0.262***	0.148**	0.153*
	(0.079)	(0.092)	(0.049)	(0.056)	(0.074)	(0.083)
R^2	0.327	0.289	0.208	0.221	0.250	0.190
Number of observations	244,061	42,433	238,103	42,249	238,103	42,249

Note: OLS estimates. Each model includes industry, year and year of birth fixed effects. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively. Standard errors clustered at the firm level are in parentheses.
Sample: Firms surviving at least 6 years, excluding non-exporting firms for columns (2), (4) and (6).

gap narrows up with the performances of late exporters after 3 years of existence. We illustrate this tendency in Table 3 in which we report the employment premia of each category of exporters compared to the non exporter firms.[17] By contrast, the gap between the performance of exporting firms (all categories confounded) and the one of non exporters increases after 6 years of existence.

Finally, we show that born globals also differ from more traditional exporters in terms of the scope and quality of their exports (Table 4). French born globals indeed have on average 101% more destinations, and 85% more export products than late exporters and they export products of higher average quality.[18] This finding pushed us to design our empirical strategy, described in the next section, such that export strategy variables enter as determinants of the probability of receiving public support along with the firm exporter status.

17. This convergence tendency is also observed when the export premia are computed in terms of turnover or labour productivity. Those additional results are reported in the Online Appendix S1.

18. In the Online Appendix (see Table S1-4), we further show that each export strategy variable is significantly associated with firm economic performance. When interacting born globals with their export scope, we find that larger scopes (both in destinations and in products) are associated with better performances. These premia are larger for born globals than for other exporting firms. We also find that product quality is associated with better firm performance, but the premium is not significantly larger for born globals than for other exporting firms.

Table 3 – **Export premia over the firm life cycle measured in terms of employment**

	Employment					
	1 to 3 years		4 to 6 years		7 and more years	
	(1)	(2)	(3)	(4)	(5)	(6)
Born globals	0.731***	0.509***	0.664***	0.397***	0.804***	0.411***
	(0.034)	(0.039)	(0.040)	(0.039)	(0.056)	(0.048)
Born exporters	0.587***	0.343***	0.576***	0.272***	0.678***	0.266***
	(0.019)	(0.026)	(0.023)	(0.026)	(0.033)	(0.030)
Late exporters	0.247***	*Ref.*	0.321***	*Ref.*	0.424***	*Ref.*
	(0.019)		(0.019)		(0.026)	
Non exporters	*Ref.*	-	*Ref.*	-	*Ref.*	-
R^2	0.192	0.221	0.232	0.221	0.203	0.221
Number of observations	70,514	12,532	69,669	11,963	97,920	17,754

Note: Each OLS estimate includes the same control variables as those in Table 2. For the sake of space saving, we do not report the coefficients on the firm control variables. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively. Standard errors clustered at the firm level are in parentheses.
Sample: Firms surviving at least 6 years, excluding non-exporting firms for columns (2), (4) and (6).

Table 4 – **Scope and quality of exports by exporter type**

	Destination scope	Product scope	Product quality
	(1)	(2)	(3)
Born globals	1.015*** (0.028)	0.851*** (0.028)	0.081* (0.046)
Born exporters	0.310*** (0.014)	0.308*** (0.015)	−0.005 (0.039)
Late exporters	*Ref.*	*Ref.*	*Ref.*
Firm size (Assets)	23.920*** (7.736)	26.930*** (4.235)	−8.125 (5.573)
Independent firm	*Ref.*	*Ref.*	*Ref.*
French ownership	0.123*** (0.012)	0.124*** (0.012)	−0.005 (0.019)
Foreign ownership	0.157** (0.071)	0.158** (0.069)	0.063 (0.097)
R^2	0.280	0.214	0.061
Number of observations	27,209	27,209	26,891

Note: OLS regressions, where the dependent variables are expressed in log for columns (1) and (2), but not for column (3) (product quality has negative values). Each regression includes the same control variables as those in Table 2. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively. Standard errors clustered at the firm level are in parentheses.
Sample: Exporting firms surviving at least 6 years, for which Customs data on the dependent variables is available.

3. Which Firms Receive Public Aid and What Impact on their Performance?

3.1. Empirical Strategy

In order to investigate the relationship between born-global status, firm economic performance and the public support granted by Bpifrance, we proceed in two main steps. First, we estimate the likelihood of receiving various types of public aid by type of exporter. Second, we estimate the impact of receiving a public support in year t on the firm performance in subsequent years.

In the first step, we estimate the following probit model on the subsample of exporting firms:

$$\begin{aligned}\Pr\left(y_{i,t}=1|Z_{i,t}\right)&=\Pr\left(Z_{i,t}\theta+u_{i,t}\geq 0|Z_{i,t}\right)\\&=\Pr\left(Z_{i,t}\theta\geq -u_{i,t}|Z_{i,t}\right)=F_{-u}\left(Z_{i,t}\theta\right).\end{aligned}\quad(1)$$

where $y_{i,t}$ is a dummy variable that takes the value 1 if firm i received public aid in year t. F is the standard normal cumulative distribution function, $F(Z_{i,t}\theta)=(z_{i,t}\theta)=\int_{-\infty}^{Z_{i,t}\theta}\frac{e^{-t^2/2}}{\sqrt{2\pi}}dt$, and $u_{i,t}\sim N(0,1)$. Z is a vector of firm-level control variables that includes *Firm export type*, *Firm size* and *Firm ownership* and our three performance variables, *Turnover, Employment* and *Labour productivity*.

In the second step, we address the relationship between performance in $t+k$ and public aid received in t for the subsample of born-global firms, by comparing their performance before and after receiving a loan or a subsidy from Bpifrance in a difference-in-difference setting. Specifically, we estimate the following equation that is derived from an event-study framework using the full performance histories of born globals:

$$\begin{aligned}Perf_{i,t}=&\sum_{k=-2}^{5}\delta_k I\left(t=t^*+k\right)Aid_i+\alpha_i+\theta_t\\&+X_{it}^{'}\beta+u_{i,t}\end{aligned}\quad(2)$$

with *Perf* alternatively one of our three performance indexes (*Turnover, Employment* and

Labour productivity). $I\left(t = t^* + k\right)$ is an indicator for whether year t is k years far from year t^* of receiving the public support, k varying between −2 and 5. Our key explanatory variable *Aid*, represents alternatively each type of aid (*innovation subsidy*, *investment loan*, *international loan* and *innovation loan*). X'_{rt} is a matrix of time-varying control variables which include *Firm size* and *Firm ownership*. We also add firm fixed effects α_i in this regression to control for all unobservable, time-invariant firm characteristics that might impact the firm's performance. θ_t is a vector of year fixed effects. In this specification, each coefficient δ_k measures the change in the performance variable between $t-2$ and $t+k$ for born globals that received an aid compared to those that did not.

3.2. Results on the Likelihood of Receiving Public Support

Based on the literature, we expect an ambiguous relationship between born-global status and the likelihood of receiving public support. On the one hand, born-global firms may have easier access to public aid because they are better able to overcome the fixed costs of preparing an aid application or because they have a higher expected benefit from aid and therefore a greater incentive to apply. Additionally, depending on their selection criteria, public investment banks might be more willing to allocate aid to higher performing firms, and we have shown that born globals perform on average better than other types of firms. On the other hand, born globals might lack domestic collateral and could be seen as less reliable or more risky borrowers.

The estimation results of equation (1) highlight this ambiguous relationship in two ways. First, the likelihood of obtaining an innovation subsidy appears higher (by 1 percentage point) for born globals than for late exporters (Table 5). This finding is consistent with the idea that born globals are more innovative than newborn firms on average, and are consequently more likely to obtain innovation subsidies from public agencies. Second, born globals also appear more likely than late exporters to receive an international loan but less likely to receive an investment loan. On the one hand, this finding is consistent with the idea that born globals may have lower fixed costs or expect higher returns to their internationalization activities than late exporters. This would incentivize them to seek out and/or this would allow them to obtain loans linked to these activities. On the other hand, it also supports the idea that being granted

Table 5 – **Likelihood of receiving public support by firm type**

	Innovation subsidy	International loan	Innovation loan	Investment loan
	(1)	(2)	(3)	(4)
Born globals	0.0103***	0.0025***	0.0003	−0.0026***
	(0.0017)	(0.0008)	(0.0008)	(0.0009)
Born exporters	0.0044***	0.0018***	0.0005	−0.0027***
	(0.0014)	(0.0006)	(0.0006)	(0.0007)
Late exporters	*Ref.*	*Ref.*	*Ref.*	*Ref.*
Firm size	−0.150	0.038	−0.176**	−0.043
	(0.195)	(0.052)	(0.084)	(0.097)
Other firms	*Ref.*	*Ref.*	*Ref.*	*Ref.*
Group with French ownership	0.0018	−0.0013**	−0.0013**	−0.0006
	(0.0015)	(0.0005)	(0.0006)	(0.0007)
Group with foreign ownership	−0.038**	−0.007	-	-
	(0.015)	(0.006)	-	-
Turnover	−0.0014	0.0017***	0.0013***	0.0013**
	(0.0014)	(0.0005)	(0.0004)	(0.0005)
Employment	0.0058***	−0.0003	0.0016***	0.0037***
	(0.0015)	(0.0005)	(0.0005)	(0.0007)
Labour productivity	0.0004	−0.0010**	0.0000	0.0000
	(0.0012)	(0.0004)	(0.0006)	(0.0007)
Mean of the dependent variable	0.62	0.15	0.15	0.74
Number of observations	38,252	22,702	27,596	38,645

Notes: The sample for these analyses is restricted to exporting firms surviving at least 6 years. The number of observations varies across the different regressions because the time coverage of the public support varies across the public supports. Columns (1) to (4) estimate the likelihood of an innovation subsidy, an international loan, innovation loan and investment loan respectively. For instance, public support started in 2005 for innovation loans and 2007 for international loans. Each model includes industry, cohort and year fixed effects. Coefficients represent marginal effects at the mean. Robust standard errors clustered at the firm level are in parentheses. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively.

investment loans may be more subject to the existence of domestic collateral; in this case, late exporters – which are by definition better established domestically than their born-global counterparts – would be in a better position to apply for and/or obtain this type of loan.

An interesting additional finding is that productivity is never a feature that favorably distinguish firms that receive support, regardless of the type of aid considered. Only firms' turnover and employment favorably distinguish firms that receive loans from their counterparts that do not. This finding suggests that selection into public loans could be related to size (through assets) more than to efficiency, which could be a sign of misallocation.

We further find that firms affiliated to a French business group are significantly less likely to obtain international and innovation loans than other firms.[19] As a matter of fact, no foreign groups' subsidiary obtained investment or innovation loans in our sample, explaining the missing coefficient in columns 3 and 4. We guess that the main reason for this is that none of these affiliates meets the eligibility criteria to be independent or owned below 25%. For the ones of them that are eligible but would not apply, as for instance a firm owned at 20%, this could be explained by the fact that new-born firms affiliated to a larger foreign company might serve as off-shored export platforms (Irarrazabal *et al.*, 2013; Tintelnot, 2017). They would then be less likely to apply for loans as they can count on resources from a large and financially robust owner. Interestingly, new firms affiliated to a foreign company are also less likely than independent firms to obtain an innovation subsidy. This can be interpreted two ways: either Bpifrance has a kind of home bias in the allocation of innovation subsidies, or new firms affiliated to foreign companies are on average more likely to be owned at more than 25% of their capital than their counterparts held by French companies, hence less likely to meet Bpifrance eligibility criteria.

In a complementary exploratory exercise (reported in the Online Appendix S2, Tables S2-4 to S2-6 – Link to Online Appendix at the end of the article), we further analyzed whether the likelihood of obtaining public funding varies with firm export strategy as an attempt to provide a better sense of the factors influencing the allocation of different types of financial aid. We find first that born globals with above median number of destinations, number of products or product quality are more likely to receive international loans. This is consistent with the fact that firms with a more offensive export strategy need financial support for their internationalization strategy. Second, we find that born globals with number of destinations above the median and those with number of products below the median are less likely to obtain investment loans. This is consistent with the idea that innovative firms, which develop a small number of highly specific products for the global market, are considered as riskier and then face higher barriers to investment loans. Finally, we find that firms with a product scope and product quality below the median are more likely to receive an innovation subsidy. This is in line with the fact that firms that face competitiveness challenges seek to innovate in order to strengthen their position.

3.3. Effect of Public Support on Born Globals' Performance

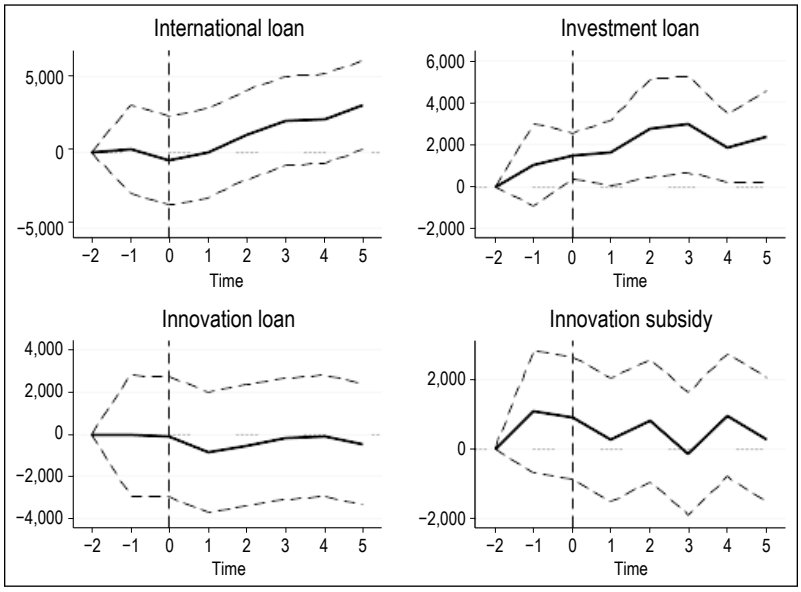
We now analyse whether born globals that benefit from public financial support have any distinctive features in terms of their *ex post* economic performance.[20] We first examine the born globals' turnover before and after receiving Bpifrance aids. Figure I shows the coefficient and confidence intervals associated with the coefficient δ_k of equation (2) for $k = -2,..,5$, estimated alternatively for each type of aid.

We find that the effect of international loans on born globals' turnover is quite substantial. Born globals that received an international loan in t^* have an average turnover €4,000k higher than born globals that did not receive this type of loan, 5 years after receiving it. We also find that born globals that received an investment loan have a higher turnover in t^*+5 (€2,000k on average) than born globals that did not receive this financial aid. However, there is already a significantly higher turnover at the time of the loan, which violates the no pre-trend differences assumption. We are more cautious on interpreting this result as a causal effect of investment loan on born globals' turnover since we cannot exclude a selection bias of the largest firms towards public aid granted by Bpifrance. On the other hand, we do not observe any significant effect of investment loans, innovation loans or innovation subsidies.

19. It is worth mentioning that the identification of a business group's subsidiary is subject to important size thresholds, as detailed in the data section, so there are very few subsidiaries in our sample (see Table A1 in Appendix for more details).

20. The same series of results for born exporters and late exporters are presented in the Online Appendix S2 (Figures S2-I to S2-VI).

Figure I – **Turnover of born globals, before and after receiving public aid**

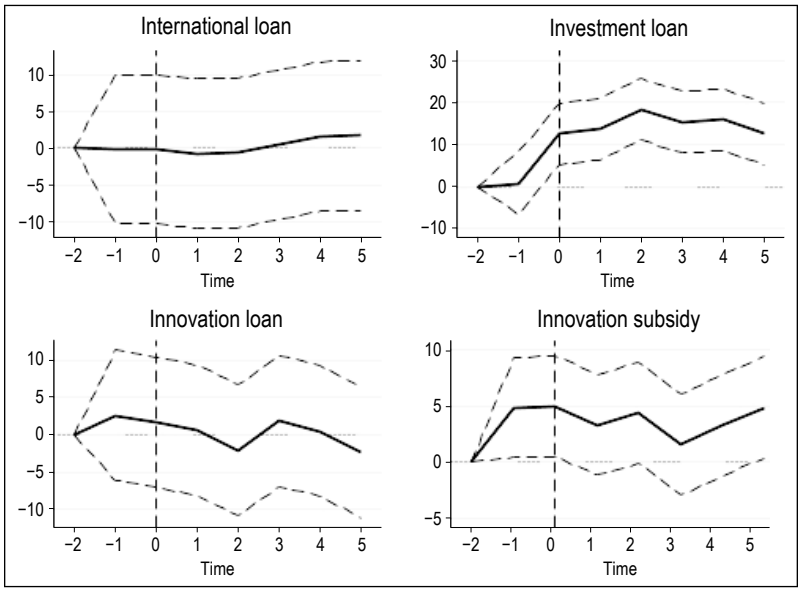


Notes: The figure shows the δ coefficient estimates of equation (2) for international, investment, innovation loans and innovation subsidies respectively, from 2 years before to 5 years after receiving it, when the depending variable is the turnover. The dotted lines represent the 95% confidence interval. The reference is year *t*=−2. We control for *Firm size* and *Firm ownership*. Estimates come from firm fixed effect OLS on the sample of born globals. Standard errors are clustered at the firm level.

We perform the same exercise when the dependent variable is the firm's total employment instead of turnover (Figure II). On average, born globals that have been granted with an investment loan in t^* employ 10 more employees than their ungranted counterparts between t^* and t^*+5. The same conclusion holds when considering the impact of innovation subsidies on employment, but with a differential of 5 employees. However, as for the effect of investment loans on born globals' turnover, we find a significant difference in employment at the time that the firm received the loan (even in t^*-1 for innovation subsidies). It is then also possible that the born globals that received this financial aid were larger than their counterparts at time t^*. It is thus difficult to attribute a causal size effect of investments loans and innovation subsidies because of a significant size difference at the time of the grant. We do not find any significant effect of international and innovation loans on employment.

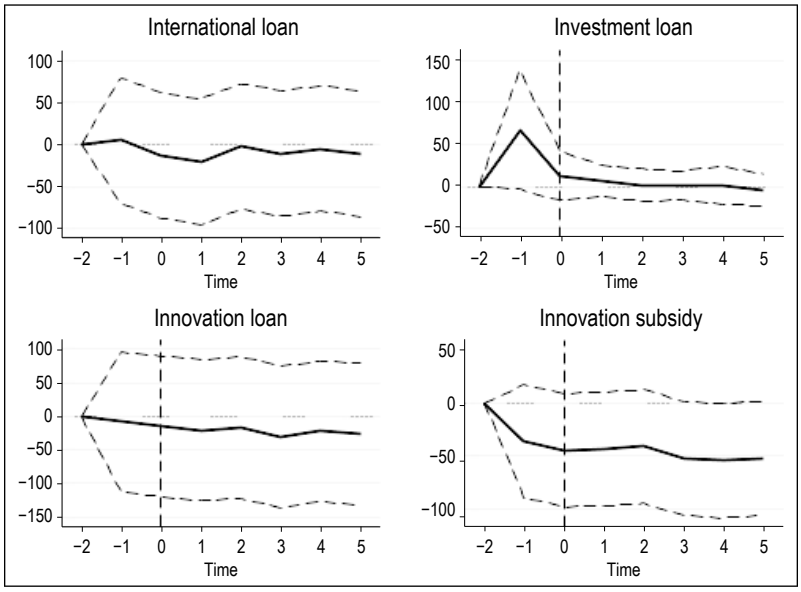
Finally, the results of the same exercise performed on *Labour productivity* (Figure III) reveal no significant difference in labour

Figure II – **Employment of born globals, before and after receiving public aid**



Notes: Same notes as in Figure I apply, except that the dependent variable is now the firm employment.

Figure III – **Productivity of born globals, before and after receiving public aids**



Notes: Same notes as in Figure I apply, except that the dependent variable is the firm labour productivity.

productivity before and after receiving public aid, whatever the public aid.

As robustness checks, and to account for pre-trend differences between granted and ungranted born globals, we report new estimators for staggered setting of the public support, as provided by Callaway & Sant'Anna (CS 2021 in Table 6) and Borusyak *et al.* (BJS 2022 in Table 6). As explained by de Chaisemartin & D'Haultfoeuille (2022), implementing two-way fixed effects regressions as we propose in equation (2), requires validating two assumptions that are, in practice, rarely satisfied. The first condition is that the parallel trends hypothesis holds and the second is that the treatment effect should be constant, between groups and over time, which is often an implausible assumption, especially in our setting where the timing of allocation of public support and the amount of public aid varies across firms. We then use two recent estimators made available by Callaway & Sant'Anna (2021) and Borusyak *et al.* (2022) to account for the limitations of the two-way fixed effects method proposed in equation (2). Both methods deal with "forbidden comparisons" in the measure of the average treatment effect (de Chaisemartin & d'Haultfoeuille, 2022).[21] They both have their pros and cons, because they rely on different parallel trends assumption. Borysyak *et al.* (2022) requires a "strong" parallel trend for every group and every period. Callaway & Sant'Anna (2021) impose a "weaker" parallel trend required only one period before the treatment, conditional on covariates. Under the parallel trends hypothesis specific to each method, the estimator proposed by Borusyak *et al.* (2022) offers a higher precision than the one of Callaway & Sant'Anna (2021). However, if trends are not exactly parallel, the estimator of Borusyak *et al.* (2022) may be more biased than the one of Callaway & Sant'Anna (2021).

As Figures I to III make clear, it is hard to immunize against differential trend for all cases. There are some significant differences between granted and ungranted born globals the period before the treatment (e.g. innovation subsidies in Figure II). Therefore, as it is customary in the literature, we only interpret coefficients from Borusyak *et al.* (2022) and Callaway and Sant'Anna (2021) in Table 6 when they are close in magnitude, because any significant difference between the two estimators implies a violation of the strong version of the parallel trend assumption (Roth *et al.*, 2022).

Table 6 shows a significant effect of innovation subsidies on employment. Born globals that receive innovation subsidies have on average 6-8 more employees than born globals that do not. We also find a positive effect of investment loans on born globals employment and turnover.[22] All other results present differences in sign and/or magnitude, which is why we prefer to remain cautious about interpreting them due to failure

21. With staggered rollout as in our setting, equation (2) leverages comparisons between firms that received public support and reference groups which had received it earlier. This represents a "forbidden comparison" because they can substantially distort the weights the estimator places on treatment effects since weights are decreasing in t.

22. We are very confident in these conclusions because they are robust to additional finer or coarser specifications. Specifically, we estimated the influence of public support on born globals alternatively using a simple fixed effect estimator and the Arellano-Bond (1991) estimator to a dynamic equation. The results are presented in the Online Appendix S2.

Table 6 – **Two-way fixed effect with heterogenous treatment effects**

	Turnover		Employment		Labour productivity	
	BJS (2022)	CS (2021)	BJS (2022)	CS (2021)	BJS (2022)	CS (2021)
Innovation subsidies	818.1*	2,178.70	**8.66*** **	**6.08***	−4.34	0.99
	(470.70)	(2,408.90)	**(2.75)**	**(3.64)**	(7.93)	(7.10)
Innovation loans	946.16	287.10	6.61**	1.75	−14.56	−5.71
	(741.21)	(755.23)	(3.00)	(2.16)	(10.76)	(4.82)
International loans	1,066.28	351.58	5.37***	1.31	−8.73	−1.54
	(690.23)	(736.30)	(1.53)	(1.28)	(10.42)	(10.77)
Investment loans	**2,040.28*** **	**1,492.34***	**15.33*** **	**9.61*** *	−22.34**	−33.83
	(398.61)	(906.90)	(1.59)	(4.43)	(9.52)	(25.10)

Note: The coefficients reported represent the average treatment effect on the treated following Callaway & Sant'Anna (2021) methodology (columns CS (2021)) and the one of Borysyak *et al.* (2022) (columns BJS (2022)). Estimates control for *Firm size, assets*, and *Firm ownership* on the sample of Born globals. Robust standard errors clustered at the firm level are in parentheses. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively.

of the strong parallel trends assumption for all periods before the event.

Overall, our results show that born globals receiving investment loans have higher turnover or employment after receiving the aid than before. However, we do not find an effect of the different types of financial aids on the labour productivity of born globals.

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In this study, we use a unique database combining comprehensive information on the production and export activities with information on the public aid granted by Bpifrance for newly established French manufacturers. Thanks to this information, we shed new light on the born-global phenomenon in French manufacturing and insights for the policy debate about how to support those specific firms, if at all.

We first provided descriptive evidence on the probability to receive different types of public aids granted by Bpifrance for different types of exporters. We also provided a first quantification of the impact of financial public aids on the relative economic performance of born globals. Our main result is as follows. Born globals are, on average, more likely to receive public support on their innovation and internationalization strategies and less likely to receive public support on their investment projects, than firms which export more gradually. By contrast, the overall return of investment loans granted by Bpifrance to born globals is high on both their turnover and employment. We interpret these results as suggesting that there is room to improve the allocative efficiency of loans granted by Bpifrance, especially those targeting the investment projects of born globals.

Regarding further research, one interesting direction would be to investigate the sources of inefficiency in the allocation of public financial support in France. This would require overcoming data limitations and accessing additional information on firms applying for public grants but being rejected. Another fruitful research avenue would consist of further investigating the extent to which the positive relationship between public support and the performance of born globals is conditioned by the amount of the financial support and by the complementary use of different instruments. Such complementary effects between investment loans and innovation subsidies to support the development strategy of start-ups have been recently demonstrated by Hottenrott & Richstein (2020) in the case of Germany. It would be interesting to further explore these complementary linkages in the case of French born globals. □

Link to the Online Appendix:
www.insee.fr/en/statistiques/fichier/7661150/ESpreprint_Bellone-et-al_OnlineAppendix.pdf

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APPENDIX

Table A1 – **Summary statistics of our key variables of interest by alternative samples**

	Raw sample		Cleaned sample		Intermediate sample		Final sample	
Firm type	% of obs.		% of obs.		% of obs.		% of obs.	
Domestic firms (Non exporters)	89.26		83.03		88.46		82.61	
Born globals	2.49		4.43		1.89		2.77	
Born exporters	5.41		8.84		5.93		8.14	
Late exporters	2.84		3.70		3.72		6.47	
Accounting variables	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*
Turnover (k€)	1,583.40	*66,450*	3,523.80	*89,633*	678.60	*2,194*	970.07	*2,516.1*
Employment	7.19	*87.72*	18.01	148.44	7.00	*10.68*	7.71	*11.21*
Labour productivity (k€)	52.12	*208.50*	55.37	*179.26*	52.88	*63.48*	53.52	*57.30*
Tangible assets (k€)	579.00	*27,812.0*	1,239.40	*37,783.0*	157.93	*879.6*	229.50	*971.3*
Intangible assets (k€)	126.81	*5,854.2*	269.17	*7,549.2*	63.47	*423.4*	80.60	*270.3*
International variables	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*
Export intensity (%)	9.99	*29.30*	12.38	21.01	7.76	*16.84*	7.94	*17.01*
Destination scope	5.14	*9.66*	6.15	*10.72*	6.05	*10.58*	8.15	*11.66*
Product scope	7.55	*31.10*	9.12	*35.45*	9.07	*35.65*	12.23	*40.18*
Market scope	20.44	*153.95*	25.64	*177.17*	25.33	*178.04*	35.69	*202.02*
Product quality	−0.69	*1.18*	−0.71	*1.15*	−0.71	*1.15*	−0.68	*1.07*
Public support variables	% of obs.	*Amount* (€)	% of obs.	*Amount* (€)	% of obs.	*Amount* (€)	% of obs.	*Amount* (€)
Innovation subsidy	0.68	134,833	0.80	135,095	0.80	134,919	0.62	197,666
Innovation loans	0.13	299,819	0.15	306,988	0.15	305,027	0.15	318,989
Investment loans	1.20	692,945	1.44	718,567	1.46	718,239	0.74	699,519
International loans	0.10	434,549	0.13	441,595	0.13	439,731	0.15	408,585
Other firm characteristics	% of obs.		% of obs.		% of obs.		% of obs.	
Operates in a MHT/HT industry	16.66		17.79		16.60		16.94	
Has an affiliation with a foreign group	0.04		0.04		0.02		0.02	
Has an affiliation with a French group	2.25		2.43		1.57		2.16	
Number of observations	1,570,869		500,933		475,931		244,061	
Number of firms	317,095		101,470		96,434		24,399	

Notes: The *Raw sample* includes all observations of newborn manufacturing firms over our period of observation. The *Cleaned sample* excludes inconsistent values defined as negative values for employment and for turnover, strictly negative values for value-added and for assets and values above 1 for the ratio of export over sales. The *Intermediate sample* additionally exclude firms with a size at inception which is in the top 1% of the firm size distribution. Finally, the *Final sample* additionally exclude firms which do not survive at least 6 years.

Table A2 – **Summary statistics of our key variables of interest by firm type, final sample**

	Born globals		Born exporters		Late exporters		Non exporters	
Accounting variables	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*
Turnover (k€)	4,195.3	*7,761.1*	2,864.9	*5,904.3*	1,731.1	3,812.9	615.5	*1,010.4*
Employment	20.1	*31.8*	16.2	*21.9*	10.8	*16.9*	6.2	*6.9*
Labour productivity (k€)	73.7	*137.2*	61.3	*64.4*	61.2	*59.1*	51.4	*47.1*
Tangible assets (k€)	1,078.8	*2,819.1*	635.3	*2,338.5*	446.0	*2,297.7*	143.9	*414.9*
Intangible assets (k€)	224.5	*799.6*	139.7	*615.5*	69.6	*333.9*	70.8	*162.1*
International variables	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*	Mean	*Std. Dev.*
Export intensity (%)	33.40	*26.6*	4.50	*9.3*	1.40	*6.3*	-	-
Destination scope	9.94	*11.6*	3.70	*4.8*	1.90	*3.6*	-	-
Product scope	8.83	*12.4*	4.30	*6.7*	2.40	*3.4*	-	-
Product quality	−0.75	*1.2*	−0.75	*1.2*	−0.72	*1.4*	-	-
Public support variables	% of obs.	*Amount* (€)	% of obs.	*Amount* (€)	% of obs.	*Amount (€)*	% of obs.	*Amount* (€)
Innovation subsidy	1.64	*81,262*	0.83	*57,337*	0.58	*35,054*	0.05	*42,281*
Innovation loans	0.38	*263,461*	0.35	*244,554*	0.22	*237,169*	0.02	*188,164*
Investment loans	0.75	*344,941*	0.62	*370,092*	0.76	*326,574*	0.10	*178,179*
International loans	0.61	*205,865*	0.32	*259,976*	0.11	*162,777*	0.00	*107,600*
Other firm characteristics	% of obs.		% of obs.		% of obs.		% of obs.	
Operates in a MHT/HT industry	41.17		32.75		28.68		13.63	
Has an affiliation with a foreign group	1.40		0.43		0.08		0.02	
Has an affiliation with a French group	39.90		34.00		20.10		6.58	

Notes: Firm categories are defined as in Table 1. Employment corresponds to the average number of full-time equivalent employees. The number of exported products is counted using the 6-digit product nomenclature. The number of destinations corresponds to the number of different foreign countries served by the firm. The number of markets corresponds to the number of distinct product-destination pairs. A lower (more negative) value of our product quality index means a higher average quality for the firm export portfolio. MHT/HT industries are identified according to the OECD definition of medium-high-tech and high-tech industries

Brexit and Breton Agricultural and Food Exports

Angela Cheptea*, Marilyne Huchet* and Lucile Henry*

Abstract – The UK left the European Union on 31 January 2020. In the long run, Brexit disrupts trade between the UK and its partners because it alters bilateral trade costs. A stronghold of the French agricultural and food sector in terms of both production and trade, the Brittany region is also an important trade partner of the United Kingdom in this sector. We quantify the potential impacts of Brexit on Brittany's exports using a general-equilibrium structural gravity model, and propose a methodology for reconstructing unavailable trade data between and within a country's regions. Expected losses are particularly high for the flagship products exported by Brittany, in particular for meat and meat products. The lower sales on the UK market are compensated by larger exports to mainly non-European partners. The new trade agreement between the European Union and the United Kingdom permitted to avoid the more significant export losses associated with no-deal scenarios.

JEL: F14, F17, F13, Q17
Keywords: Brexit, agricultural and food trade, structural gravity, infra-regional analysis, Brittany

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Brittany has historic ties with the United Kingdom. As early as in 1828, onion producers from the Roscoff region exported most of their production to England. Since the 1960s, the agriculture and agri-food industries have played a central role in the Breton economy. These sectors remain one of the main pillars of the Breton industrial model, along with the manufacture of electrical and electronic appliances, the automobile and shipbuilding industries. Although Brittany is primarily specialized in livestock farming, the region also ranks first in terms of vegetable production in France. Accordingly, in 2019, Brittany produced 34,900 tonnes of veal calves (20% of French production), 204,158 tonnes of cauliflower (80% of French production) and 179,164 tonnes of tomatoes (27% of French production) (Agreste-Draaf Bretagne, 2020)

The UK's withdrawal from the European Union raises numerous questions on the nature of its future trade relations with both Brittany and France. The United Kingdom has long been one of Brittany's key trade partners in the agricultural and food sector. According to regional customs data, in 2019 Brittany ran a € 120 million trade surplus with the United Kingdom in this sector.[1]

The British decided to leave the European Union (EU) in a referendum hold on 23 June 2016. After many twists and postponements, the country effectively left the EU on 31 January 2020. EU law continued to apply on a transitional basis in the United Kingdom from 1 February to 31 December 2020. On 30 December 2020, the President of the European Commission, the President of the European Council, and the British Prime Minister have signed a joint trade and cooperation agreement, ratified on the same day by the British Parliament. From 1 January 2021, this agreement governs the economic relationships between the United Kingdom and the EU. Negotiations have focused mainly on trade arrangements and the agreement is based on the principle of free trade: no customs duties and no quotas for trade in goods. However, withdrawal from the EU entails the re-establishment of border checks and customs formalities. Therefore, the cost of accessing the British market for exported Breton products are expected to increase. Companies willing to export to the United Kingdom must comply with the sanitary and phytosanitary formalities that have been introduced gradually from 1 January 2021. The latter include health certificates for products of animal origin, stamps and other requested information on products and packaging. Also, sea ports in Northern Ireland have introduced customs checks on products arriving from Great Britain. Sanitary and phyto-sanitary requirements and related formalities are detailed in the UK's guide for border controls on trade with the EU, the "Border Operating Model".[2]

Costs associated with customs clearance could thus increase for some agri-food products due to the additional border checks introduced to ensure compliance with importer's (EU or UK) regulations in terms of food safety, and animal and plant health. Two types of additional costs result from this: costs induced by clearing goods through customs, and time delays required to complete customs clearance. These additional costs can be reduced, but not eliminated (Matthews, 2017). This increase in trade costs will generate changes in trade flows, not only between the UK and its partners, but also indirectly between the latter, e.g. by redirecting trade flows from the UK to third markets. Furthermore, new agreements concluded by the UK with non-European partners can reduce their costs of accessing the UK market and reinforce this diversion of trade.

The impact of Brexit on trade flows between the UK and EU countries has been extensively investigated by recent studies (e.g. Dhingra *et al.* (2017) for the UK, Lawless & Morgenroth (2019) and Cheptea & Huchet (2019) for the EU). Few studies focus on the agricultural sector (Bellora *et al.*, 2017; Choi *et al.*, 2021). All these studies find a strong negative impact on the British economy and a lesser impact on the EU, unevenly distributed across Member States. Graziano *et al.* (2021) also highlighted that uncertainty about the UK's trade policy with its partners during the negotiation and transition phases has hurt its trade with the EU. This uncertainty has affected as well non-European countries and the negotiation of new preferential trade agreements by the UK (Graziano *et al.*, 2020). The effects of Brexit on the agricultural and food sector have been investigated in the literature mainly for the UK, and less for European countries, including France.

In the present article, we quantify the impact of Brexit on Breton exports. First, Brittany is one of the largest French regions in terms of agricultural production (even after the French territorial reform of 2015) and the leading region in terms of agri-food industry turnover. Second, the United Kingdom is an important outlet for

1. Source: French customs, 571 Foreign trade statistics. DRAAF Bretagne. https://draaf.bretagne.agriculture.gouv.fr/Commerce-exterieur
2. https://www.gov.uk/government/publications/the-border-operating-model

Brittany's agricultural and food products (8% of Breton agri-food exports, in 5th place behind Italy, Spain, China and Belgium in 2015). New trade agreements negotiated by the United Kingdom with non-EU countries reduce their costs for accessing the British markets. The liberalization of the UK market can make French and Breton suppliers lose the preferential access they enjoyed before Brexit, erode their UK market shares, and push them to find alternative outlets. Up to date, only two studies have evaluated the impacts of Brexit on Brittany, CESER (2017) and CESER (2016), both consisting of very descriptive analyses that provide an overview of the Breton economy without examining potential sector-level differences.

This article aims to quantify the effects of five trade policy scenarios on the main groups of agricultural and food products exported by Brittany. Regional studies are rare in the literature and focus on effects at the macro level, disregarding differences across sectors or types of products. For example, Chen *et al.* (2018) develop an index of exposure that illustrates the vulnerability of EU regions and countries to Brexit, while Capello *et al.* (2018) measure the losses, in terms of GDP, stemming from the reintroduction of legal and administrative barriers for European regions. Our article has also a strong methodological contribution: we propose a method for predicting the lacking data on intra- and inter-regional trade flows necessary for estimating the effects of Brexit at region level.

The article is structured as follows. Section 1 discusses the main stylised facts in the agricultural and food sector. We identify Brittany's flagship products, in terms of both production and exports. In section 2, we describe the methodology for quantifying the effects of Brexit, and the considered scenarios. Section 3 summarises the employed data and the results from our reconstruction of missing data. Section 4 presents simulation results and changes in trade patterns induced by the five Brexit scenarios. In the end, we draw some concluding remarks.

1. Food and Agriculture in Brittany: Flagship Products and Preferred Trade Partners

This section employs data for 2015, the year preceding the June 2016 referendum on the United Kingdom's exit from the European Union, known as Brexit. Hereinafter, the term *agri-food* encompasses agriculture, fisheries and agri-food industries (AFIs).

Brittany is a leading French region in terms of agricultural production and of agri-food turnover. It is the largest French region in terms of livestock farming. It is also a major region for vegetables production. According to Agreste (2016), the flagship fruits and vegetables produced in Brittany are tomatoes (240,063 t in 2015) and cauliflowers (236,805 t). The region also produces shallots (36,607 t), artichokes (26,136 t), lettuce (13,802 t), leeks (8,734 t), endives (7,301 t), cabbages (7,168 t), strawberries (4,281 t), and yellow and red onions (3,613 t). In 2015, it produced 19% of French fresh vegetables. Brittany also originates 49% of the French production of eggs, 26% of pigs, 27% of poultry, 21% of cow milk, and 20% of calves. A large share of these products are processed locally. As a result, Breton agri-food industries amount to 8% of the total value added (VA) of French agri-food industries.[3] Brittany also stands out for its share in animal feed production and fish industry (21% of the French VA in both cases), meat industry (20%), and the processing of fruit and vegetables (15%) – Figure I.

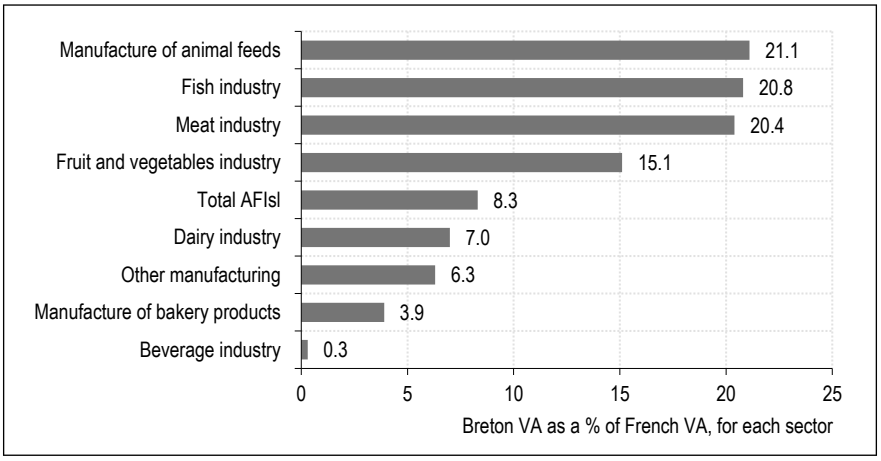
AFIs account for 6.6% of Brittany's VA, but only 2.4% for entire France (Figure II). For agriculture and fishing, these shares amount to 3.3% and 1.7%, respectively. According to the French National Institute for Statistics and Economic Studies (INSEE), the share of Brittany's workforce employed in agriculture and AFIs largely exceeds the French average. In 2014, the agriculture accounted for 2% of Brittany's employees, compared to 1% in metropolitan France. AFIs accounted for 6% in Brittany, compared to only 2% in metropolitan France.

The meat industry is the main pillar of Breton AFIs, accounting for 40% in terms of value added, followed by dairy products and animal feeds (Figure III). In contrast, the beverage industry plays a more significant role at national level than in Brittany, mainly due to wines. Unsurprisingly, the fish and seafood industry is more prominent in Brittany. Note that all four *departments* of Brittany have an extensive seashore, which makes Brittany the French region with the longest coastline.

Figures A1 and A2 of the Appendix show that meat and meat products are the most exported products by Brittany, both in terms of value and share of country-level exports (€ 1.4 billion in 2015, i.e. nearly 25% of French exports in this category), followed by dairy products (€ 601 million in 2015, i.e. 8.1% of French

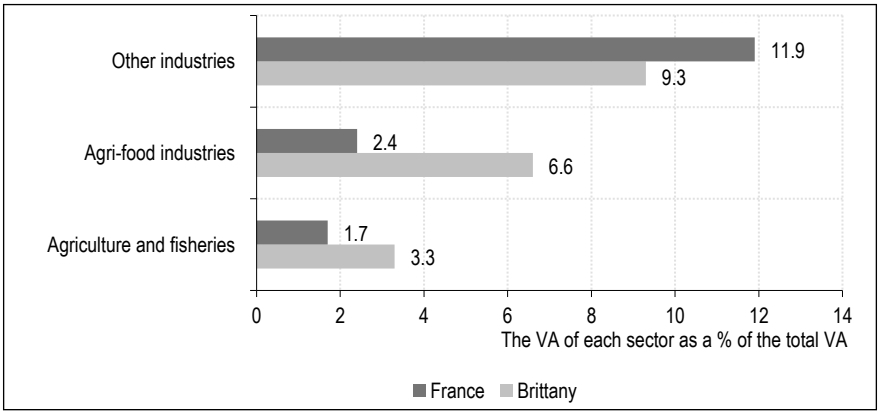
3. Source: DRAAF and INSEE data, 2015.

Figure I – **Contribution of Breton AFIs to the French value added**



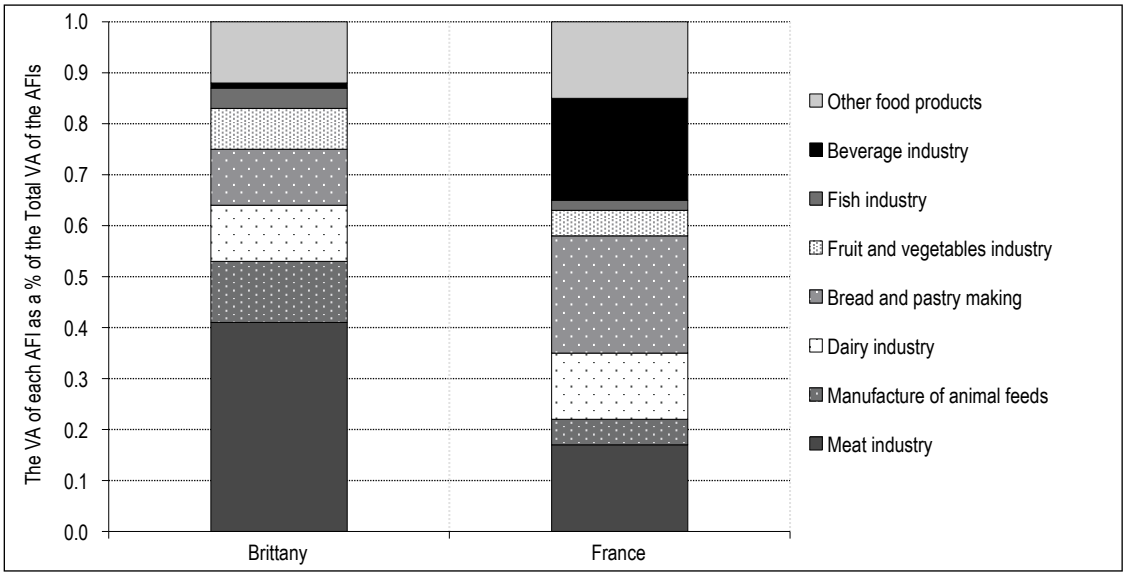
Sources: 2015 ESANE (*Élaboration des statistiques annuelles d'entreprises* – Elaboration of Annual Company Statistics) data, INSEE, authors' calculations.

Figure II – **Distribution of Breton and French value added by sector of economic activity**



Sources: 2015 ESANE (*Élaboration des statistiques annuelles d'entreprises* – Elaboration of Annual Company Statistics) data, INSEE, authors' calculations.

Figure III – **Distribution of the value added of the Breton and French AFIs**



Sources: 2015 ESANE (*Élaboration des statistiques annuelles d'entreprises* – Elaboration of Annual Company Statistics) data, INSEE, authors' calculations.

exports in this industry). Brittany is responsible for nearly 12.5% of the seafood exports of France (€ 234 million in 2015). Differently, the region produces and exports very few wines, which represent the top agri-food product exported by France (€ 9.5 billion in 2015), with the United Kingdom and the United States as main destinations.

Apart from Brittany, the United Kingdom is a major trade partner also for France, attracting 9.4% of French agri-food exports. This makes it the third largest destination for French exports in this sector, behind Germany (10.7%) and Belgium (10.5%). The main products exported by France to the UK are beverages (€ 1.8 billion, primarily wines), followed by dairy products (€ 0.6 billion) and processed cereal-based foods (€ 0.3 billion). We expect these products to depict a higher level of vulnerability to Brexit.

Finally, Brittany runs a large surplus in trade in agricultural and food products, including with the UK, which is at the same time an important supplier of some product categories (notably fish and seafood products, cereals, and meat). In 2015, Brittany's agri-food trade with the UK generated a trade surplus of 99 million euro.

The top five destination markets of Breton agri-food exports are within Europe. They include the UK, which absorbed 9.3% of Brittany's agri-food exports in 2015, i.e. € 326 million (see Figure A3 of the Appendix). This position of the UK remained stable over time, at around 8% of the region's exports from 2014 to 2018. The rest of France (without Brittany) also exports mainly to European, the main destinations, but their ranking slightly differs (Figure A3 of the Appendix). Brittany's exports to the UK are dominated by meat and cereal products (see Figure A4 of the Appendix). At country level, wines are the crown jewel of French exports to the UK, followed by dairy and cereal products.

2. Methodology and Scenarios

In the present article, we quantify the impact of Brexit on Brittany's agri-food exports. We define five trade policy scenarios reflecting the lengthy negotiations and uncertainty that preceded Brexit, and employ a general-equilibrium structural gravity model similar to Anderson *et al.* (2018). We consider Brittany and the rest of France (without Brittany) as separate trade partners.

2.1. Structural Gravity Model

We estimate the effects of Brexit on trade flows between Brittany and its partners, and compare them to the effects on trade between the rest of France and the same partners. In addition to the direct effects of Brexit, induced by changes in UK's bilateral trade costs, the model also accounts for the indirect impact on trade flows between other countries through adjustments in terms of prices, expenditure and output levels. Similarly to Anderson *et al.* (2018), our model assumes a representative consumer with homothetic preferences, which maximises a utility function with constant elasticity of substitution (CES) under budgetary constraints and market clearance. This optimisation program yields the following expression for the exports in year t of country i to destination j, expressed in consumer prices:

$$X_{ijt} = Y_{it} E_{jt} \left(\frac{\tau_{ijt}}{\Pi_{it} P_{jt}} \right)^{1-\sigma} \epsilon_{ijt}. \quad (1)$$

This equation applies for each group of products traded by countries. For simplicity of presentation, we omit the product index. E_{jt} is the expenditure in year t of country j consumers on products of all origins, Y_{it} is the output of country i in year t, $\sigma > 1$ is the elasticity of substitution between products from different countries of origin, and ϵ_{ijt} is a zero-mean error term. The term $\left(\tau_{ijt} / \Pi_{it} P_{jt}\right)$ captures the level of trade costs between i and j relative to the average trade costs of i and j with all their partners. It consists of three elements: bilateral trade costs, τ_{ijt}, associated to shipping goods from i to j and to the applied trade policy (customs duties and non-tariff measures), and two multilateral resistance terms (outward and inward), Π_{it} and P_{jt}, introduced by Anderson & van Wincoop (2003).[4] Π_{it} reflects the level of access of global consumers (from all destinations, including i) to products from origin i; P_{jt} reflects the level of access to the global market (to products of all origins, including j) of consumers in destination market j. These terms represent export (import) price indices weighted by expenditure (output), and capture the impact of trade costs on consumers (producers) in each country.[5] To estimate the effect of a change in trade policy, it is therefore important to integrate not only direct effects on affected bilateral relationships, but also indirect effects on other markets.

4. Anderson & van Wincoop (2003) show that the amount of trade between two countries depends not on the absolute level of bilateral trade costs, but on their level relative to the countries' average trade costs with all world partners.

5. $\Pi_{it}^{1-\sigma} = \sum_j \left(\frac{\tau_{ijt}}{P_{jt}} \right)^{1-\sigma} E_{jt}$; $P_{jt}^{1-\sigma} = \sum_i \left(\frac{\tau_{ijt}}{\Pi_{it}} \right)^{1-\sigma} Y_{it}$.

In this model, the impact of Brexit results from a change in trade costs. In line with the international trade literature, we use a trade costs specification that includes geographical distance, $dist_{ij}$ (capturing transport and related costs that increase with distance), the presence of a common land border, $contig_{ij}$, a common official language, $langcom_{ij}$, a common colonial past, $comcol_{ij}$, customs duties applied by the importing country on products from the exporting country, $tariff_{ijt}$, and the dissimilarity in the number of non-tariff measures (NTMs) of type m in the two countries, $dist\_MNT_{ij}^{m}$ (regulatory distances):

$$\tau_{ijt}^{1-\sigma} = dist_{ij}^{\beta_1} \exp\left(contig_{ij}\right)^{\beta_2} \exp\left(langcom_{ij}\right)^{\beta_3} \exp\left(comcol_{ij}\right)^{\beta_4} \cdot \left(1 + tarif_{ijt}\right)^{1-\sigma} \prod_m \exp\left(dist\_MNT_{ijt}^{m}\right)^{\delta_m} \quad (2)$$

We insert this expression of trade costs in equation (1), and regroup terms specific to the exporting and importing country to obtain:

$$X_{ijt} = dist_{ij}^{\beta_1} \exp\left(contig_{ij}\right)^{\beta_2} \exp\left(langcom_{ij}\right)^{\beta_3} \exp\left(comcol_{ij}\right)^{\beta_4} \cdot \left(1 + tarif_{ijt}\right)^{1-\sigma} \prod_m \exp\left(dist\_MNT_{ijt}^{m}\right)^{\delta_m} \psi_{it}\, \chi_{jt}\, \epsilon_{ijt} \quad (3)$$

The structural gravity model offers a general equilibrium perspective on trade. Accordingly, it requires the use of a complete data matrix on all explained and explanatory variables, including domestic flows (purchases by country i consumers of goods produced in i). Countries collect few or no data on trade flows within the country. We use the structure of the model and the estimated values of parameters to reconstruct the value of these flows.[6]

2.2. Estimation Strategy and Scenarios

We estimate the effects of Brexit using 2012–2015 data. Our sample runs from 2012, when the effects of the 2008–2009 economic crisis have been absorbed in most countries, until 2015, the year before the Brexit vote. The estimation strategy presented in this section relies on observed data and predicted data for intra-national trade flows, including flows between Brittany and the rest of France. The computation of the latter is explained in the Online Appendix (link to the Online Appendix at the end of the article).

In order to correctly quantify the impact of Brexit, the counterfactual value of trade is compared not to the value observed before Brexit, but to the value of the trade predicted by the model using pre-Brexit trade costs.[7] First, we compute this benchmark level for all variables in the model. For this, we estimate equation (3) on all trade flows (international and domestic), and use the estimated values of parameters, $\widehat{\beta_1}$ - $\widehat{\beta_4}$, $\widehat{\sigma}$, $\widehat{\delta_m}$, and of importer-year and exporter-year fixed effects, $\widehat{\psi_{it}}$ and $\widehat{\chi_{jt}}$, to obtain the benchmark value for each trade flow. From these results, we compute the benchmark level of annual expenditures and outputs (using budgetary constraints and market clearance), and of multilateral resistance terms.[8]

We define five scenarios for the trade costs (corresponding to different levels of import tariffs and NTMs) between the United Kingdom and its partners (Table 1). Four hypothetical scenarios cover a wide range of potential post-Brexit trade policies, while a fifth scenario illustrates the trade policy actually adopted by the UK. The first four scenarios are obtained by matching two outcomes for the UK's trade policy with the EU – a free trade agreement close to the status quo, or a return to World Trade Organization (WTO) rules with bilateral trade subject to import tariffs and NTMs that parties apply to their most-favoured-nation (MFN) partners – and two outcomes for the UK's trade policy with non-EU countries – a replication of current EU agreements (Box 1), or preferential trade agreements with main non-European partners and a return to WTO rules with the rest of countries.

The fifth scenario is shaped by the new EU-UK Trade and Cooperation Agreement (EU-UK TCA) applied since 1 January 2021,[9] the UK's new preferential trade agreements with third countries, and the new United Kingdom Global Tariff (UKGT) that replaced the EU's Common External Tariff (CET) for British imports from all countries with which the UK had no separate trade agreement.[10] British exports to the latter group of countries remain subject to WTO rules (MFN tariffs). For this scenario, we assume that non-tariff measures remain unchanged for all trade relationships.

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6. See the Online Appendix for further details.

7. Economic models predict the value of variables of interest with a certain level of error. For this reason, comparing counterfactual values with observed values can generate biased results because any statistical error in the model would be attributed to the effect of Brexit.

8. $E_{jt}^{R} = \sum_i \hat{X}_{ijt}$; $Y_{it}^{R} = \sum_j \hat{X}_{ijt}$; $\left(P_{jt}^{R}\right)^{1-\sigma} = E_{jt}^{R} / \hat{\chi}_{jt}$; $\left(\Pi_{it}^{R}\right)^{1-\sigma} = Y_{it}^{R} / \hat{\psi}_{it}$.

9. Based on recent sector-level data on the use of trade preferences by EU countries (Nilsson & Preillon, 2018), we assume that 84% of the EU-UK agri-food trade (within each product line) complies with the rules of origin and is subject to zero import tariffs, while the remaining 16% are subject to MFN tariffs.

10. The UKGT benefits mainly non-EU partners, as it offers them an improved access to the British market, with respect to their pre-Brexit situation, and to their access to the EU market. Except a small number of sensitive products, the UKGT brings to zero all customs duties smaller than 2% in the CET, increasing the share of products imported by the United Kingdom with zero customs duties from 27% (under the CET) to 47% (under the UKGT).

Table 1 – **Proposed scenarios**

		The United Kingdom's trade relations with:	
	Scenario	EU-27	Non-EU countries
(S1)	Quasi status quo	Free trade agreement	Replication of EU agreements[(a)] WTO rules with other countries
(S2)	Fortress United Kingdom	WTO rules	Replication of EU agreements[(a)] WTO rules with other countries
(S3)	Liberalised trade with the EU and main non-EU partners	Free trade agreement	Preferential trade agreements with main developed countries[(b)] WTO rules with other countries
(S4)	Liberalised trade only with main non-EU partners	WTO rules	Preferential trade agreements with main developed countries[(b)] WTO rules with other countries
(S5)	Current policy	EU-UK TCA[(c)]	New UKGT[(d)] New preferential trade agreements (PTAs)

Notes: [(a)] Countries with which the EU has a free trade agreement.
[(b)] United States, Australia, New Zealand, Switzerland, Chile and Israel.
[(c)] EU-UK Trade and Cooperation Agreement (EU-UK TCA).
[(d)] New United Kingdom General Tariff (UKGT).

Each scenario is characterised by a counterfactual level of trade costs, τ_{ijt}^{CFL}, detailed in Table A1 of the Appendix. Following Anderson *et al.* (2018), we first compute the impact of Brexit on the directly affected trade flows (i.e. the ones experiencing a change in trade costs) by replacing τ_{ijt} with τ_{ijt}^{CFL} in equation (3). Next, we use the structure of the model to compute the adjustments to the new trading environment of partners' expenditures, outputs, and multilateral resistances. We introduce the new values of these variables in equation (3), and repeat the procedure until the factory-gate price[11] of each partner converges towards an equilibrium level.[12] This permits us to compute the counterfactual trade flows in general equilibrium. Finally, the gap with respect to the benchmark value of trade flows represents the impact of Brexit for each scenario.

11. The price excluding trade costs, $p_{it} = p_{ijt} / \tau_{ijt}$, also known as the producer price.

12. Table S3-2 of the Online Appendix summarises the estimated values of model parameters. The estimated value of the elasticity of substitution σ is not always statistically significant and makes the model converge for only ten of the analysed product groups. For the remaining six groups, we set σ equal to the value estimated by Raimondi & Olper (2011), which ranges from 2.8 for wines to 9.2 for fish and seafood products.

Box 1 – **The Rules for Post-Brexit Trade**

Failure to reach a trade agreement between the UK and the EU means that bilateral trade becomes subject to the same rules that parties apply to partners with whom they have no preferential trade relationships. These rules correspond to their commitments made during multilateral negotiations under the General Agreement on Tariffs and Trade (GATT) and the WTO. They consist in applying the most-favoured-nation status, which reflects the GATT/WTO fundamental principle of non-discrimination between partners. However, as an exception to this principle, member countries may establish preferential trade rules with one or more partners with whom they negotiate a trade agreement, subject to its notification to the WTO. Free trade between EU countries represents such an exception.

For WTO countries, the most-favoured-nation status corresponds to the highest level of trade protection a country can apply to its partners. Partners with whom the country has reached a trade agreement, shares a free trade area, a customs union or a higher level of economic integration enjoy an improved market access, consisting of lower or zero customs duties and of similar or identical non-tariff measures. Thus, a return to WTO rules means a significant increase in bilateral trade costs between the UK and the EU.

As a member of the EU, the UK could not independently negotiate and sign trade agreements. Leaving the EU permits the country to define its own trade policy with all partners. At the same time, it permits the UK to continue to apply some of the EU's 40 free trade agreements, renegotiate the terms of these agreements, or conclude new agreements with other countries. Since its withdrawal from the EU on 31 January 2020, the UK has signed 20 *continuity* agreements covering 50 countries or territories and about 8% of British foreign trade. Agreements signed with the United States, Australia and New Zealand are *Mutual Recognition Agreements*, not free trade agreements. Mutual recognition permits to improve trading opportunities and facilitate trade between involved countries. This type of agreement also generates large benefits through accelerated border checks and simplified formalities for customs clearance. New trade opportunities seem to emerge between the United Kingdom and the United States, as well as with the 53 Commonwealth nations that represent 2.7 billion people and a GDP similar to that of the EU, according to the International Monetary Fund (IMF).

3. Data

The final database used for simulations is obtained by combining data from several sources. Data on international trade flows come from BACI (*Base pour l'Analyse du Commerce International*) developed by the CEPII research centre (CEPII – Gaulier & Zignago, 2010). We select the bilateral flows between the 57 top exporters and importers of agri-food products from 2012 to 2015, covering 76% of the global trade in this sector.[13] We divide France into two regions: Brittany and the rest of France (without Brittany), and obtain a panel of 58 trading partners. Data on the imports and exports of Brittany and France without Brittany are obtained from the French customs (Le Kiosque, DGDDI). BACI data are disaggregated by products defined according to the Harmonized System 6-digit classification (HS6), while customs data use a less narrow definition, the 4-digit French Product Classification (CPF4). To reconcile the two data sources, we aggregate trade flows into 16 product groups using the official correspondence table between HS6 and CPF4 classifications. Table 2 lists the product groups and their corresponding level of EU-UK trade protection for each Brexit scenarios. Domestic trade flows between Brittany and the rest of France, as well as within each region, are not observed.[14] We predict these flows by solving the structural gravity model using observed data on trade flows and trade costs components. This procedure is explained in section S1 of the Online Appendix.

We use a trade cost structure that combines import tariffs, non-tariff measures, and standard variables on bilateral linkages (geographic distance, common border, language, and colonial past). Data on the latter come from the CEPII's GeoDist database (Mayer & Zignago, 2011). Data on applied import tariffs and non-tariff measures are obtained from the Trade Analysis Information System (TRAINS) database of United Nations Conference on Trade and Development (UNCTAD), and come in a HS6 product disaggregation.[15] For non-tariff measures, we compute regulatory distances following the methodology introduced by Cadot *et al.* (2015) (Box 2). We aggregate import tariffs and computed regulatory distances from the HS6 level into the 16 agri-food product groups listed above. The values of these variables obtained for France apply to the foreign trade of both Brittany and the rest of France.[16]

13. This choice is dictated by the availability of data on non-tariff measures.
14. We cannot employ survey data on the transportation of goods within France because they are not representative (they cover only a small number of sectors and regions). We can neither compute inter- and intra-region trade flows using data on regional production. The output of agricultural goods is collected only in of quantity, and covers both the output sold directly in the market and the output transformed into more processed products.
15. https://unctad.org/topic/trade-analysis/non-tariff-measures/NTMs-data-dissemination
16. We compute separate distances for the two regions only with their closest neighbours: Germany, Switzerland, Italy, Belgium, the United Kingdom, and Ireland. For Brittany, we take the average distance from the main cities of these countries to Rennes; for the rest of France, we take the average distance to the 22 main French cities situated outside Brittany.

Table 2 – **Trade protection between Brittany/France/EU and the United Kingdom by scenario and product group**

	S1		S2		S3		S4		S5	
Product group	Tariff	NTM	Tariff	NTM	Tariff	NTM	Tariff	NTM	Tariff	NTM
Live animals	0.00	0.19	11.18	0.19	0.00	0.19	11.18	0.19	0.76	0.19
Meat and meat products	0.00	0.17	21.22	0.17	0.00	0.17	21.22	0.17	5.73	0.17
Dairy products	0.00	0.19	31.97	0.19	0.00	0.19	31.97	0.19	6.05	0.19
Fish and seafood products	0.00	0.21	8.55	0.21	0.00	0.21	8.55	0.21	1.79	0.21
Cereals and cereal products	0.00	0.00	12.33	0.00	0.00	0.00	12.33	0.00	1.22	0.00
Grain processing products	0.00	0.02	29.74	0.02	0.00	0.02	29.74	0.02	4.67	0.02
Oil and fats	0.00	0.00	6.95	0.00	0.00	0.00	6.95	0.00	1.16	0.00
Fruit and vegetables	0.00	0.00	10.92	0.00	0.00	0.00	10.92	0.00	1.61	0.00
Fruit and vegetable preparations	0.00	0.00	14.44	0.00	0.00	0.00	14.44	0.00	2.05	0.00
Coffee, spices, cocoa and sugar	0.00	0.02	11.25	0.02	0.00	0.02	11.25	0.02	1.34	0.02
Tobacco	0.00	0.06	22.97	0.06	0.00	0.06	22.97	0.06	8.01	0.06
Non-alcoholic beverages	0.00	0.00	13.31	0.00	0.00	0.00	13.31	0.00	1.25	0.00
Wines	0.00	0.00	7.61	0.00	0.00	0.00	7.61	0.00	0.81	0.00
Other alcoholic beverages	0.00	0.00	4.54	0.00	0.00	0.00	4.54	0.00	1.04	0.00
Other preparations	0.00	0.01	14.61	0.01	0.00	0.01	14.61	0.01	1.37	0.01
Other products	0.00	0.09	3.32	0.09	0.00	0.09	3.32	0.09	0.69	0.09
Total	*0.00*	*0.06*	*14.13*	*0.06*	*0.00*	*0.06*	*14.13*	*0.06*	*2.50*	*0.06*

Notes: "Tariff" and "NTM" columns indicate, respectively, the average counterfactual level of customs duties (in %), and regulatory distance for type C non-tariff measures (pre-shipment checks and formalities) under the five scenarios. These are the only elements of trade costs that change after Brexit.

For each scenario, we compute counterfactual trade costs by replacing in equation (2) the pre-Brexit import tariffs duties and regulatory distances with their corresponding hypothetical values. We assume that concluded trade agreements reduce import tariffs and regulatory distances for pre-shipment checks and formalities between the participating countries. Similarly, we model the return to WTO rules by an increase in these variables (see Table A1 of the Appendix for details).

4. Brittany's Vulnerability to Brexit

We use the methodology detailed above to estimate the effects of a change in trade costs induced by Brexit for each of the defined five scenarios. Table 3 (resp. A2) reports the change in exports from Brittany and the rest of France to different partners for each product group, expressed in relative terms (resp. in monetary terms). Changes in relative terms (in per cent) account for differences in size between these two regions. To compare impacts across product groups, one needs to control for their different contribution to the exports of each region. Results permit to identify the products most severely exposed to Brexit, and to quantify export losses and gains for the two regions.

Recall that import tariffs and the regulatory distance for pre-shipment checks and formalities are the only trade cost elements that vary across scenarios. Accordingly, for product groups for which these two variables have a non-significant effect on trade, the model will produce no impact. In particular, we can obtain similar variations in a region's exports under different scenarios. For some product groups (tobacco, other preparations, wines, and live animals), the regulatory distance for pre-shipment checks and formalities has a positive effect on trade, which may lead to counter-intuitive results.

4.1. Effect on Total Exports

Overall, scenarios S2 and S4 (no EU-UK trade deal) are the most harmful for the exports of Brittany and the rest of France, regardless the product. Brittany's overall exports are estimated to decrease by 3.54% (€ 123.51 million) and 4.97% (173.38 million euro), respectively. For the rest of France, the estimated drop are much smaller in relative terms (–1.07% and –1.58%), but larger in values (€ 673.61 million and € 1.24 billion) due to its larger economic size. Whatever the scenario, Brittany's flagship products – meat and meat products, and to a smaller extent dairy products – are highly exposed to Brexit.[17] Oppositely, the most exported products by the rest of France are slightly (wines and other alcoholic beverages) or moderately impacted (cereals, cereal products, and dairy) in relative terms. Still, we expect the exports

17. This result is in line with the findings by CESER (2016), which identifies the Brittany's meat sector as the most exposed to Brexit.

Box 2 – **The Impact of Non-Tariff Measures**

We measure the impact of non-tariff measures (NTMs) on trade through the regulatory distance introduced by Cadot *et al.* (2015), which reflects the dissimilarity between the measures imposed by the exporter and the importer. This choice differs from the usual practice in the literature, which captures non-tariff measures by their ad valorem equivalent, frequency rate, or coverage ratio. Ad valorem equivalents of NTMs are frequently computed in separate analyses, relying on assumptions different or even contradictory to those of the model that estimates their effects on trade, and using data that may differ in terms of covered period, country panel, level of analysis, etc. We also do not employ NTMs frequency or coverage rates because of their collinearity with the country fixed effects of the structural gravity model. Moreover, existing studies incorporate NTMs into their trade policy scenarios by assuming ad hoc, unexplained changes in the level of NTMs (e.g. a 25%, 50%, or 75% increase in the level of NTMs due to Brexit). For the present analysis, it seems more relevant to use as reference partners trading under most-favoured-nation terms. We consider the dissimilarity of NTMs to be very strong (the strongest) in this case, because of lacking instruments/initiatives for unifying the partners' NTMs (due to the absence of a trade agreement).

The regulatory distance is the difference between the number of NTMs of a given category applied by the exporting and the importing country for a given product, transposed on a 0-1 scale. A distance of 1 means that the two countries apply totally different NTMs, while a value of 0 indicates that they apply exactly the same number of NTMs of the same category. We calculate this distance for each category of NTMs defined at the most granular level of the UNCTAD classification and aggregate results by major classes (types) of NTMs most frequently applied in agricultural and food trade.

We include four types of NTMs into our specification of trade costs: sanitary and phyto-sanitary measures (SPSs), technical barriers to trade (TBTs), pre-shipment checks and other formalities, and measures that directly affect the quantity of imported products (import licences, quotas, import restrictions, etc.). SPSs and TBTs often apply to the same products and at similar levels. Therefore, the regulatory distances corresponding to these two types of NTMs are highly correlated, but the omission of either of them would generate an omitted variable bias. To overcome this problem, we use the average of these two regulatory distances.

Table 3 – **Changes in Exports and Sales from Brittany and the Rest of France (%)**

		Brittany					Rest of France				
		Exports + domestic sales					Exports + domestic sales				
Product group	σ	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Live animals	3.50	0.52	−0.15	−0.05	−1.00	0.09	−0.08	−0.21	−0.63	−1.11	−0.49
Meat and meat products	5.00	−0.74	−7.01	−1.37	−10.06	−3.99	−0.43	−6.18	−0.98	−9.18	−3.59
Dairy products	4.57	−0.09	−1.52	0.02	−2.47	−0.22	−0.02	−1.03	0.10	−2.01	−0.14
Fish and seafood products	9.20	−0.37	−1.61	−0.30	−1.56	−0.34	−0.25	−1.12	−0.19	−1.08	−0.23
Cereals and cereal products	4.40	0.00	−2.00	−0.16	−2.28	−0.28	0.00	−1.76	−0.13	−2.03	−0.26
Grain processing products	6.51	−0.02	−1.98	−0.12	−2.68	−0.43	−0.01	−1.68	−0.07	−2.32	−0.40
Oil and fats	4.80	0.00	−0.36	−0.16	−0.52	−0.11	0.00	−0.19	−0.12	−0.31	−0.09
Fruit and vegetables	5.02	0.00	−1.36	−0.02	−1.38	−0.41	0.00	−1.19	−0.02	−1.20	−0.36
Fruit and vegetable preparations	6.53	0.00	−1.97	0.22	−1.67	−0.37	0.00	−1.55	0.18	−1.30	−0.31
Coffee, spices, cocoa and sugar	5.56	0.02	−1.20	0.20	−0.97	−0.41	0.01	−0.66	0.19	−0.44	−0.32
Tobacco	3.39	0.23	0.00	0.27	0.04	0.66	0.28	−0.11	0.32	−0.07	0.74
Non-alcoholic beverages	3.60	0.00	−0.75	0.00	−0.75	−0.09	0.00	−0.33	0.02	−0.31	−0.06
Wines	2.80	0.00	0.09	0.63	0.66	0.01	0.00	0.10	0.63	0.67	0.01
Other alcoholic beverages	5.00	0.00	−0.49	−3.00	−3.38	0.01	0.00	−0.32	−2.81	−3.02	0.01
Other preparations	2.65	0.04	−0.37	0.09	−0.31	−0.11	0.02	−0.26	0.08	−0.20	−0.13
Other products	5.94	−0.31	−0.49	−0.47	−0.65	−0.29	−0.30	−0.46	−0.45	−0.62	−0.27
Total		*−0.32*	*−3.54*	*−0.56*	*−4.97*	*−1.73*	*−0.03*	*−1.07*	*−0.25*	*−1.58*	*−0.35*
		Exports to the United Kingdom									
Product group	σ	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Live animals	3.50	12.59	−0.37	13.83	0.07	9.82	12.74	−0.31	13.97	0.00	9.94
Meat and meat products	5.00	−9.30	−38.59	−16.04	−48.66	−17.29	−9.35	−38.70	−16.08	−48.76	−17.34
Dairy products	4.57	−2.19	−23.55	−2.36	−28.32	−3.99	−2.21	−23.62	−2.37	−28.46	−4.03
Fish and seafood products	9.20	−12.27	−51.95	−9.20	−49.43	−10.80	−12.33	−52.07	−9.24	−49.55	−10.85
Cereals and cereal products	4.40	0.00	−22.39	−2.33	−24.56	−4.21	0.00	−22.46	−2.34	−24.64	−4.23
Grain processing products	6.51	−0.44	−49.50	−4.35	−59.56	−11.24	−0.45	−49.69	−4.36	−59.73	−11.31
Oil and fats	4.80	0.00	−16.50	−3.10	−19.21	−2.37	0.00	−16.58	−3.10	−19.29	−2.38
Fruit and vegetables	5.02	0.00	−18.26	0.03	−18.26	−5.06	0.00	−18.47	0.03	−18.47	−5.13
Fruit and vegetable preparations	6.53	0.00	−28.98	2.28	−26.31	−4.66	0.00	−29.05	2.30	−26.37	−4.68
Coffee, spices, cocoa and sugar	5.56	0.47	−24.62	1.58	−23.43	−6.28	0.47	−24.78	1.60	−23.59	−6.33
Tobacco	3.39	6.36	−15.25	5.95	−15.73	12.29	6.37	−15.24	5.96	−15.73	12.29
Non-alcoholic beverages	3.60	0.00	−9.33	0.02	−9.35	−0.74	0.00	−9.50	0.02	−9.52	−0.76
Wines	2.80	0.00	−3.06	1.32	−1.41	−0.32	0.00	−3.06	1.32	−1.40	−0.32
Other alcoholic beverages	5.00	0.00	−11.32	10.04	−0.98	0.95	0.00	−11.45	9.97	−1.17	0.95
Other preparations	2.65	0.96	−9.10	0.08	−10.05	−1.68	0.96	−9.11	0.08	−10.06	−1.68
Other products	5.94	−4.95	−7.88	−6.11	−9.13	−4.59	−4.99	−7.95	−6.15	−9.19	−4.63
Total		*−3.75*	*−27.69*	*−6.58*	*−32.16*	*−8.77*	*−0.56*	*−16.42*	*−0.04*	*−16.57*	*−3.22*
		Exports (sales) to the EU (excluding the UK and France)									
Product group	σ	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Live animals	3.50	−0.83	−0.40	−1.27	−1.04	−1.21	−0.64	−0.32	−1.12	−1.11	−1.03
Meat and meat products	5.00	0.66	−3.24	0.42	−6.04	−2.34	0.58	−3.50	0.33	−6.30	−2.42
Dairy products	4.57	0.21	0.53	0.41	−0.23	0.09	0.19	0.33	0.38	−0.52	0.06
Fish and seafood products	9.20	0.91	3.59	0.78	3.47	0.76	0.85	3.33	0.73	3.22	0.71
Cereals and cereal products	4.40	0.00	0.44	0.10	0.39	0.01	0.00	0.33	0.09	0.27	−0.01
Grain processing products	6.51	0.04	0.98	0.19	0.42	−0.25	0.03	0.08	0.12	−0.53	−0.38
Oil and fats	4.80	0.00	0.69	0.07	0.74	0.00	0.00	0.60	0.06	0.64	0.00
Fruit and vegetables	5.02	0.00	1.10	−0.05	1.05	0.23	0.00	0.84	−0.04	0.79	0.16
Fruit and vegetable preparations	6.53	0.00	1.94	−0.19	1.67	0.11	0.00	1.80	−0.17	1.55	0.08
Coffee, spices, cocoa and sugar	5.56	−0.04	2.08	0.10	2.25	0.12	−0.04	1.81	0.12	2.00	0.07
Tobacco	3.39	−0.03	0.60	0.01	0.65	0.30	−0.02	0.60	0.02	0.65	0.30
Non-alcoholic beverages	3.60	0.00	1.94	0.08	2.00	−0.05	0.00	1.31	0.05	1.34	−0.06
Wines	2.80	0.00	0.53	0.59	1.15	0.00	0.00	0.53	0.59	1.15	−0.01
Other alcoholic beverages	5.00	0.00	3.54	0.26	3.58	0.04	0.00	3.37	0.17	3.33	0.04
Other preparations	2.65	−0.07	0.37	−0.01	0.43	−0.26	−0.06	0.36	−0.01	0.42	−0.27
Other products	5.94	0.08	0.17	−0.05	0.03	0.10	0.05	0.12	−0.08	−0.02	0.07
Total		*0.35*	*−0.61*	*0.28*	*−1.89*	*−0.87*	*0.05*	*0.52*	*0.12*	*0.22*	*−0.19*

Table 3 – *(contd.)*

		Brittany					Rest of France				
		Exports (sales) to the rest of the world									
Product group	σ	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Live animals	3.50	−0.17	0.73	−1.90	−1.29	0.19	−0.07	0.73	−1.92	−1.53	0.24
Meat and meat products	5.00	2.00	9.62	6.10	12.95	2.71	1.90	9.00	5.53	11.82	2.53
Dairy products	4.57	0.03	2.95	0.04	3.28	0.67	0.02	2.86	−0.03	3.05	0.72
Fish and seafood products	9.20	0.96	4.74	0.28	4.22	0.94	0.88	4.42	0.23	3.92	0.88
Cereals and cereal products	4.40	0.00	0.93	0.17	0.93	1.03	0.00	0.82	0.15	0.79	1.00
Grain processing products	6.51	0.04	8.69	0.79	10.69	2.66	0.03	7.77	0.70	9.68	2.62
Oil and fats	4.80	0.00	1.43	0.01	1.38	0.25	0.00	1.32	−0.03	1.24	0.24
Fruit and vegetables	5.02	0.00	4.69	0.10	4.88	1.49	0.00	4.25	0.08	4.41	1.39
Fruit and vegetable preparations	6.53	0.00	6.89	−0.11	7.07	1.47	0.00	6.63	−0.13	6.79	1.44
Coffee, spices, cocoa and sugar	5.56	−0.05	2.92	−0.25	2.77	1.32	−0.05	2.52	−0.21	2.41	1.18
Tobacco	3.39	0.06	0.58	0.14	0.68	−0.11	0.06	0.59	0.15	0.69	−0.11
Non-alcoholic beverages	3.60	0.00	0.92	−0.10	0.86	0.23	0.00	0.89	−0.03	0.91	0.26
Wines	2.80	0.00	1.06	0.37	1.12	0.17	0.00	1.05	0.37	1.12	0.17
Other alcoholic beverages	5.00	0.00	−1.10	−7.79	−8.59	−0.20	0.00	−1.23	−7.78	−8.67	−0.20
Other preparations	2.65	−0.08	0.98	0.26	1.34	0.57	−0.07	0.95	0.24	1.28	0.54
Other products	5.94	0.83	1.26	1.10	1.57	0.73	0.71	1.08	0.93	1.33	0.64
Total		*0.87*	*5.40*	*2.57*	*6.84*	*1.56*	*0.09*	*1.36*	*−1.43*	*−0.16*	*0.49*
		Exports (sales) to Brittany									
Product group	σ	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Live animals	3.50	−0.83	−0.40	−1.23	−1.04	−1.24	−0.70	−0.33	−1.11	−1.11	−1.13
Meat and meat products	5.00	0.69	−3.21	0.42	−6.07	−2.31	0.64	−3.39	0.36	−6.25	−2.37
Dairy products	4.57	0.21	0.47	0.40	−0.33	0.09	0.19	0.38	0.39	−0.53	0.05
Fish and seafood products	9.20	1.01	3.97	0.93	3.90	0.86	0.94	3.71	0.89	3.65	0.81
Cereals and cereal products	4.40	0.00	0.35	0.09	0.28	−0.02	0.00	0.26	0.08	0.18	−0.04
Grain processing products	6.51	0.04	0.40	0.14	−0.18	−0.32	0.03	0.00	0.13	−0.60	−0.41
Oil and fats	4.80	0.00	0.76	0.12	0.86	0.02	0.00	0.66	0.11	0.76	0.01
Fruit and vegetables	5.02	0.00	1.12	−0.04	1.07	0.23	0.00	0.86	−0.03	0.82	0.16
Fruit and vegetable preparations	6.53	0.00	2.15	−0.18	1.89	0.12	0.00	2.05	−0.16	1.81	0.10
Coffee, spices, cocoa and sugar	5.56	−0.05	2.32	0.13	2.53	0.12	−0.04	2.10	0.14	2.31	0.07
Tobacco	3.39	−0.06	0.68	−0.01	0.74	0.27	−0.05	0.68	−0.01	0.74	0.27
Non-alcoholic beverages	3.60	0.00	1.25	0.06	1.29	−0.02	0.00	1.06	0.05	1.10	−0.04
Wines	2.80	0.00	0.33	0.61	0.96	−0.01	0.00	0.33	0.61	0.96	−0.01
Other alcoholic beverages	5.00	0.00	3.95	0.89	4.60	0.05	0.00	3.80	0.83	4.41	0.05
Other preparations	2.65	−0.06	0.34	−0.02	0.38	−0.27	−0.06	0.33	−0.02	0.38	−0.28
Other products	5.94	0.24	0.42	0.14	0.32	0.25	0.20	0.35	0.10	0.25	0.21
Total		*0.30*	*−0.39*	*0.25*	*−1.57*	*−0.70*	*0.12*	*0.21*	*0.17*	*−0.43*	*−0.33*
		Exports (sales) to the Rest of France									
Product group	σ	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Live animals	3.50	−0.93	−0.42	−1.33	−1.00	−1.32	−0.80	−0.35	−1.20	−1.07	−1.22
Meat and meat products	5.00	0.58	−3.60	0.26	−6.45	−2.44	0.53	−3.77	0.21	−6.64	−2.50
Dairy products	4.57	0.21	0.53	0.41	−0.21	0.13	0.20	0.44	0.40	−0.41	0.09
Fish and seafood products	9.20	0.98	3.85	0.90	3.78	0.84	0.92	3.59	0.86	3.53	0.78
Cereals and cereal products	4.40	0.00	0.35	0.09	0.28	−0.02	0.00	0.25	0.08	0.17	−0.04
Grain processing products	6.51	0.04	0.34	0.13	−0.24	−0.31	0.03	−0.06	0.12	−0.66	−0.40
Oil and fats	4.80	0.00	0.69	0.08	0.76	0.01	0.00	0.60	0.07	0.66	0.00
Fruit and vegetables	5.02	0.00	0.96	−0.04	0.91	0.20	0.00	0.69	−0.04	0.66	0.13
Fruit and vegetable preparations	6.53	0.00	1.95	−0.17	1.72	0.11	0.00	1.85	−0.15	1.64	0.08
Coffee, spices, cocoa and sugar	5.56	−0.04	2.13	0.14	2.35	0.14	−0.04	1.90	0.16	2.14	0.09
Tobacco	3.39	−0.07	0.71	−0.03	0.76	0.25	−0.07	0.71	−0.03	0.77	0.25
Non-alcoholic beverages	3.60	0.00	1.27	0.08	1.35	0.03	0.00	1.08	0.08	1.16	0.02
Wines	2.80	0.00	0.40	0.60	1.01	−0.01	0.00	0.40	0.60	1.01	−0.01
Other alcoholic beverages	5.00	0.00	3.84	0.77	4.37	0.05	0.00	3.69	0.70	4.17	0.05
Other preparations	2.65	−0.07	0.41	−0.02	0.46	−0.25	−0.07	0.40	−0.02	0.45	−0.26
Other products	5.94	0.22	0.39	0.12	0.28	0.23	0.18	0.32	0.08	0.21	0.19
Total		*0.34*	*−1.36*	*0.21*	*−2.96*	*−1.21*	*0.05*	*0.94*	*0.23*	*0.81*	*−0.10*

Notes: The effects of the five Brexit scenarios described in Table 1. In scenario S1, exports of live animals from Brittany to the United Kingdom would have increased by 12.59%.

of these products, except wines, to significantly diminish in monetary values.

For the actually implemented trade policy, represented by scenario S5, meat and meat products are the most harshly affected by Brexit. This product group features a 3.99% (€ 55.49 million) drop in the exports of Brittany and a 3.59% (€ 124.36 million) drop for the rest of France. Effects in relative terms are generally stronger for Brittany than for the rest of France. Notable differences are observed for fish and seafood products, dairy products, fruit and vegetables, other fruit and vegetable preparations, and coffee, spices, cocoa and sugar. Live animals stand out of this tendency, as the exports of these products increase slightly for Brittany but decrease for the rest of France.

4.2. Effect on Exports to Various Partners

Unsurprisingly, under all scenarios, exports to the United Kingdom suffer the strongest impact, both for Brittany and for the rest of France. Within each product group, the model predicts similar relative changes in the two regions' exports.

Under scenario S5, the sales of both regions to the British market fall by about 17% for meat and meat products, by 11% for processed grain products, and fish and seafood products, by 6% for coffee, spices, cocoa and sugar, and by 5% for fruit and vegetables. Positive impacts for live animals (10%) and tobacco (12%) arise due to the positive effect of the regulatory distance for pre-shipment checks and formalities estimated for these product categories, which outweighs the effect induced by the small increase in import tariffs.[18] Nevertheless, these two groups account for a small fraction of Brittany's exports (see Figure A1 of the Appendix). More pronounced differences between the two regions emerge when we account for the share of each product group in regions' exports. Brittany's industry of meat and meat products suffers, by far, the largest drop in exports; the main export losses for the rest of France are distributed across five product groups (see Table A2 of the Appendix). Unlike in the case of Brittany, the product group most heavily exported by the rest of France (wines) is very little affected. Contrary to suppliers of cereal and dairy products, Brexit does not penalize the French wine producers.

Across product groups, the decrease in exports to the United Kingdom is differently diverted to other destinations. For example, for fish and seafood products, losses on the British market are offset by homogeneous percentage increases in trade with other partners (France, Europe, and the rest of the world), which correspond to amounts of diverted trade proportional to the size of destination markets. For fruit and vegetables and dairy products, most of this trade is diverted to the rest of the world, and to a smaller degree to EU countries and France, both in percentage and value terms. For cereals and cereal products, only non-EU markets benefit from this diversion, while exports to the EU remain virtually unchanged. We obtain opposite effects for meat and meat products, and grain processing products, namely a decrease in sales on European and French markets, but an increase in exports to the rest of the world. The main destinations of this trade diversion are China, Japan, and the United States, characterised by expanding meat consumption.

4.3. Comparison of Scenarios

Scenarios S1 and S3, which assume the reintroduction of pre-shipment checks and formalities but not of import tariffs on EU-UK trade, whether the UK concludes PTAs with non-EU partners or not, generate a small overall impact on the exports of Brittany and of the rest of France. A sizable effect is obtained only for the monetary increase in the exports of other alcoholic beverages from the rest of France to the rest of the world, under scenario S3. Overall, predicted changes in Breton and French exports are larger under scenarios S2 and S4, which assume the introduction of both import tariffs and border controls between the EU and the United Kingdom due to the absence of a trade agreement. For example, under the latter scenarios exports to the UK would have decreased by approximatively 50% for meat and meat products, and fish and seafood products. The milder effects under scenario S5 place the implemented trade policy midway between the extreme scenarios mentioned above. Hence, the bilateral trade agreement signed by the EU and the UK appears as a compromise accepted by the two parties.

Comparing the results of scenarios S1 and S3 permits to understand how changes in the UK's trade policy towards non-EU countries affect Breton and French exports. Losses in terms of total exports are larger when the United Kingdom concludes preferential trade agreements with its main extra-EU partners, both for Brittany (€ 11.11 million under scenario S1 vs € 19.70 million under scenario S3) and the rest

18. In scenario S5, 16% of flows between France and the UK are subject to non-zero import tariffs due to rules of origin requirements.

of France (€ 20.42 million under scenario S1 vs € 156.32 million under scenario S3). Brittany's export losses concentrate on the British market, while for the rest of France these losses arise mainly from smaller amounts exported to non-EU destinations. Still, for some product groups, the above-mentioned PTAs reduce competition on extra-EU markets, allowing Breton and French suppliers to reinforce their market shares.

By comparing scenario S1 to scenario S2, and S3 to S4, highlights the importance of keeping import tariffs between the EU and the UK equal to zero. Abandoning bilateral free trade (scenarios S2 and S4) deteriorates the competitiveness of Breton and French products on the UK market, leading to a contraction of exports in all product groups. The sharp decrease in trade, by nearly one third for Brittany and by 16% for the rest of France, arises from the introduction of EU's very high MFN import tariffs (cf. Table 2). The drop in exports reaches 60% for grain processing products, and about 50% for fish and seafood products, and meat and meat products. Losing the preferential access to the British market also affects the performance of Breton and French exports to other markets. Brittany's sales on European markets decrease (€ −13.42 million under scenario S2 and € −41.3 million under scenario S4) due to a strong competition effect on meat and meat products. Indeed, all EU producers of these goods redirect to the intra-EU market the amounts they can no longer sell to the UK, which reinforces competition and drives prices downwards.[19] In the case of the rest of France, these losses are offset by higher exports in other product groups. Introducing imports tariffs on trade with the United Kingdom improves the export performance of both regions on non-EU markets. This reveals that large part of the exports of Brittany and the rest of France are diverted to these destinations.

4.4. Robustness of the Results

The magnitude of the effects described above depends on value of the elasticity of substitution, which is here equal to the price elasticity of demand. A higher elasticity yields larger effects, especially under scenarios S2, S3 and S4, which assume a significant increase in import tariffs on the UK's trade with the EU and/or third countries.[20] Nevertheless, the ranking of scenarios by their impact and by how exports to the UK are redirected to alternative destination markets remains broadly unaltered.[21]

Furthermore, altering the assumptions on the level of NTMs under different scenarios only slightly modifies the results, and does not affect our main findings. For example, if we assume that the UK's Preferential Trade Agreements (PTAs) with non-EU partners reduce the regulatory distance to 25% of its pre-Brexit level (instead of 50% assumed earlier), we obtain a minor amplification of export evolutions discussed above.[22] Assuming a similar drop in import tariffs between PTAs partners (to 25% of their pre-Brexit level) generates more pronounced changes in our results.[23] This indicates that Breton and French exports are more sensitive to changes in the level of tariffs than of NTMs.

If we exclude NTMs from the model and define the scenarios exclusively by changes in import tariffs, the effects of Brexit diminish significantly for all scenarios.[24] We conclude that although most of the impact of Brexit discussed above is generated by changes in imports tariffs on the UK's trade with EU and non-EU partners, NTMs also play an important role. Still, even when we modify the original scenarios, the conclusions expressed in this section, reached by comparing the evolutions of exports across destination markets, product groups, and scenarios, remain valid.

Finally, in the Online Appendix, we test the robustness of results under the implemented trade policy scenario (S5) by correcting the computation of domestic trade flows for the "border effect" documented in the literature, according to which a disproportionally larger amount of trade takes places within national borders. In this case, we find no evidence of a trade diversion towards EU and French markets, and losses in exports

19. We find a similar effect on the domestic market (sales to Brittany and to the rest of France).

20. A higher value of elasticity yields a stronger changes in exports.

21. For most product groups, including the flagship products of Breton exports (meat and meat products, and dairy products), the elasticity employed in this article is close to its value estimated by Fontagné et al. *(2022). For main product groups the most exported by the rest of France (cereals and cereal products, and wines), using the Fontagné* et al. *(2022) elasticity would slightly increase the drop in exports to the UK, and the amounts diverted to other markets, resulting into a negligible change in the effect on total exports. The few product groups for which Fontagné* et al. *(2022) estimate higher elasticities account for a small share of each region's exports. Therefore, our choice of elasticities does not affect the robustness of results.*

22. This modification of scenario S3 yields a stronger drop in Breton exports to the UK (7.12% vs 6.58%), less diversion to the EU market (0.26% vs 0.28%), and more diversion to the rest of the world (2.94% vs 2.57%). The net effect on exports to all partners is slightly smaller than wiht the unmodified scenario (–0.61% vs –0.56%). We find similar effects when we apply the same modification to scenario S4. The evolutions of the exports of the rest of France change marginally in both cases.

23. Under this variant of scenario S3, Breton exports to all destinations decrease by 2.35% (vs 0.56% in the unmodified scenario). The similar variant of scenario S4 predicts a stronger drop in exports to the UK, but larger diversions to other markets, resulting in a lower net effect on total exports than previously (−2.66% vs −4.97%).

24. In this case, Breton agri-food exports to all partners contract by 2.95% under scenario S2 (vs 3.54%), by 0.20% under scenario S3 (vs 0.56%), by 4.80% under scenario S4 (vs 4.97%), and by 0.81% under scenario S5 (vs 1.73%). Scenario S1 becomes now obsolete beacuse it assumes that i import tariffs remain at the pre-Brexit level.

to the UK are compensated by an increase in exports to extra-EU destinations alone.

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The Brittany's agri-food sector is strongly oriented to exports. The United Kingdom is a major destination for Brittany. Therefore, the region is in high need of identifying and quantifying the potential risks induced by Brexit and the associated challenges.

This article analyses the evolution of Brittany's agricultural and food exports after the United Kingdom's exit from the EU. We estimate the effects of Brexit for sixteen product groups of this sector using a structural gravity model and 2012–2015 data. We consider four extreme trade policy scenarios, which cover a wide range of possible trade policy outcomes, and a fifth scenario depicting the actual trade policy implemented since 1 January 2021, after the conclusion of a new EU-UK Trade and Cooperation Agreement. We address the lack of data on domestic trade flows, between and within a country's regions, and propose a method for predicting these data. For that, we use the structure of the model and parameter values obtained through estimations on observed trade flows.

Since Brittany and France feature a very different product composition of exports, we compute for each scenario the impact on agricultural and food exports both as percentages and monetary values. Overall, the implemented trade policy scenario emerges as a compromise outcome, producing effects of intermediate magnitude within the range defined by the extreme scenarios. We estimate Brittany's losses in agricultural and food exports generated by Brexit at € 60 million, halfway between the € 11–173 million losses obtained under the other scenarios. Although the rest of France incurs higher monetary losses due to its economic size, the percentage impact is much smaller than for Brittany.

Under all scenarios, meat and meat products stand out as the most severely impacted industry of Brittany. These products ranks top in Brittany's exports (40% of the value added of Brittany's AFIs in 2015), the region alone originating a quarter of French exports of meat and meat products. Unsurprisingly, exports to the UK market suffer the most. Under the implemented trade policy, the model predicts a 17% (€ 21 million) drop in Breton exports of meat and meat products. These exports may have dropped by 50% (€ 60 million) if different trade policies were adopted. The exports in other product categories, such as fish and grain processing products, would have suffered a strong decrease in percentage terms, but losses in monetary terms would have been considerably below those for meat because of their lower share in region's exports. Except for meat and live animals, Brexit determines suppliers to redirect their exports from the UK to the European and French markets, but above all to extra-EU destinations. Brittany's exports of meat and meat products are redirected exclusively to non-EU markets. Our results point out that Breton meat producers require a stronger support from policy makers in order to adjust to the UK's withdrawal from the EU and seize new trade opportunities. □

Link to the Online Appendix:
www.insee.fr/en/statistiques/fichier/7713592/ES540_Cheptea-et-al_OnlineAppendix.pdf

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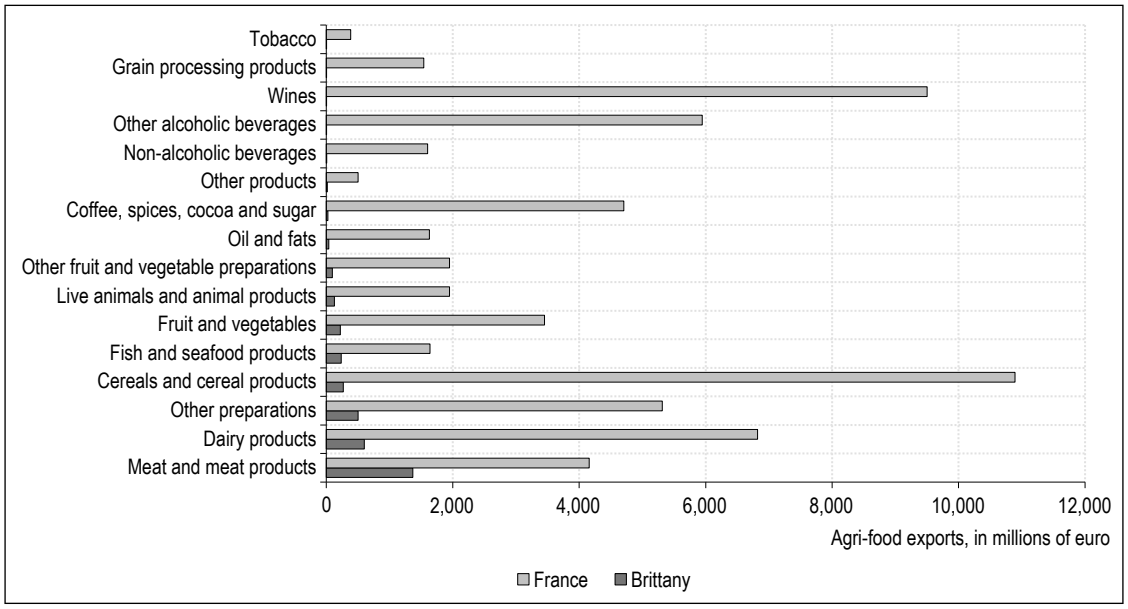
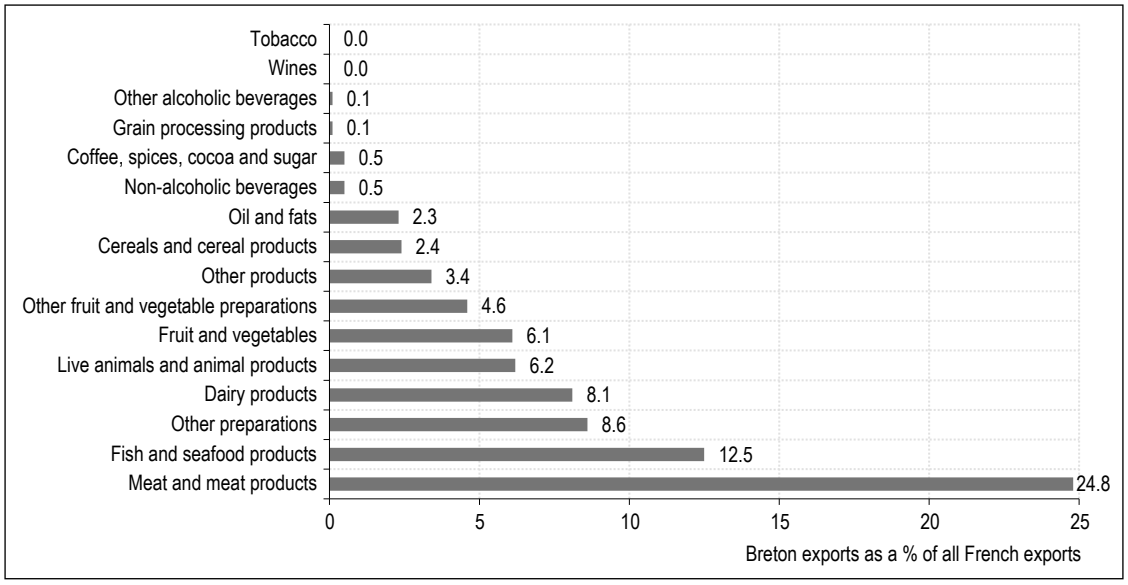
APPENDIX

Figure A1 – **Agri-food exports from Brittany and the rest of France (In millions of euro - 2015)**



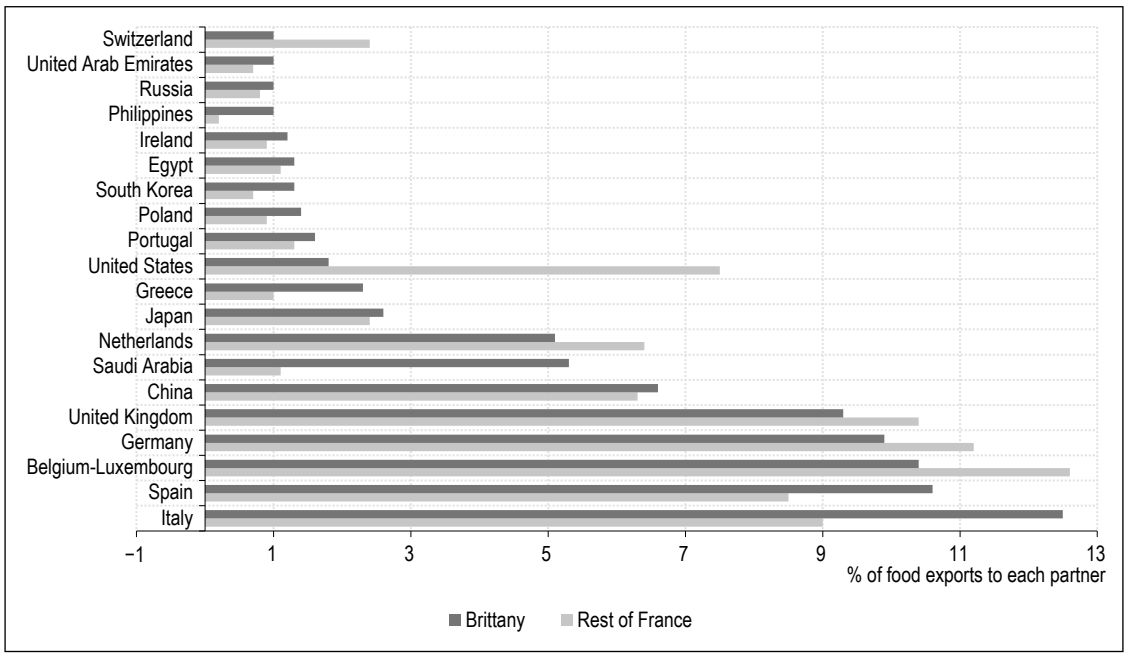
Sources: Regional customs and BACI.

Figure A2 – **Brittany's share of French exports in 2015**



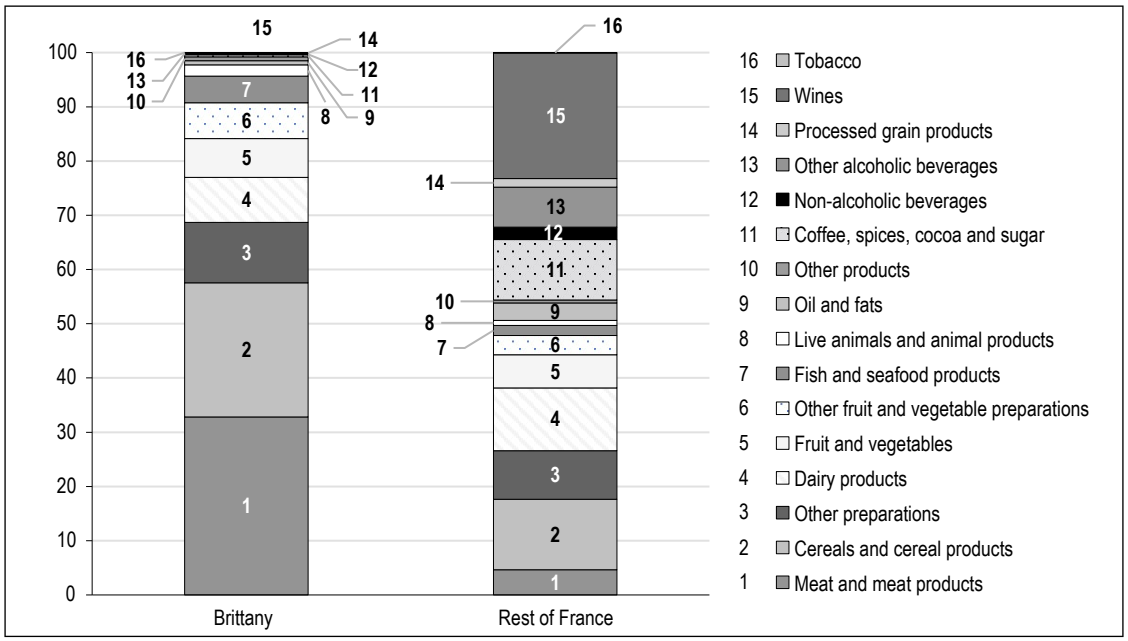
Sources: Regional customs and BACI.

Figure A3 – **Share of each destination in the agri-food exports of Brittany and the rest of France in 2015**



Sources: Regional customs and BACI.

Figure A4 – **Composition of the exports from Brittany and the rest of France to the United Kingdom in 2015**



Sources: Regional customs.

Table A1 – **Trade costs in the scenarios**

	Scenario	The United Kingdom's trade relations with:	
		EU27	Non-EU countries
(S1)	Quasi status quo	zero tariffs NTMs as for MFN status	unchanged tariffs unchanged NTMs
(S2)	Fortress United Kingdom	MFN tariffs NTMs as for MFN status	unchanged tariffs unchanged NTMs
(S3)	Liberalised trade with the EU and the main non-EU partners	zero tariffs NTMs as for MFN status	With the main developed countries[(a)]: ½ MFN tariff; NTMs as ½ MFN status With other countries: unchanged tariffs; NTMs as for MFN status
(S4)	Liberalised trade with only the main non-EU partners	MFN tariffs NTMs as for MFN status	With the main developed countries[(a)]: ½ MFN tariffs; NTMs as ½ MFN status With other countries: unchanged tariffs; NTMs as for MFN status
(S5)	Current policy	84% of flows: zero tariffs 16% of flows: MFN tariffs unchanged NTMs[(c)]	PTA[(b)]: negotiated preferential tariffs Other imports from the UK: UKGT tariffs[(c)] Other imports from the EU: MFN tariffs unchanged NTMs

Notes: [(a)] United States, Australia, New Zealand, Switzerland, Chile and Israel.
[(b)] New preferential trade agreements (PTAs) negotiated by the United Kingdom.
[(c)] New United Kingdom General Tariff (UKGT).

Under scenarios S1 to S4, the MFN NTM system means that the distance between the UK's non-tariff measures and those of the EU-27 is equal to the average level observed between the UK (EU) and the countries with which it does not have a preferential trade agreement (countries with which trade is under the MFN system). In scenario S5, we consider the distances between the UK and the EU-27 to be unchanged, compared to the period before Brexit (2012–2015), so as to reflect the announcement of flexibilities granted in terms of customs declarations for companies as well as the effort to digitalise those formalities.

Table A2 – **Changes in Exports from Brittany and the Rest of France (in millions of euro)**

		Brittany						Rest of France				
		Exports (sales) to all partners										
Product group	Share	S1	S2	S3	S4	S5	Share	S1	S2	S3	S4	S5
Live animals	3.1	0.57	−0.16	−0.05	−1.10	0.10	3.2	−1.64	−4.29	−12.88	−22.69	−10.02
Meat and meat products	39.9	−10.29	−97.49	−19.05	−139.90	−55.49	5.5	−14.90	−214.09	−33.95	−318.01	−124.36
Dairy products	19.2	−0.60	−10.19	0.13	−16.56	−1.48	11.0	−1.39	−71.67	6.96	−139.87	−9.74
Fish and seafood products	7.0	−0.90	−3.93	−0.73	−3.81	−0.83	2.4	−3.72	−16.65	−2.82	−16.06	−3.42
Cereals and cereal products	6.8	0.00	−4.74	−0.38	−5.41	−0.66	17.7	0.00	−196.90	−14.54	−227.11	−29.09
Grain processing products	0.0	0.00	−0.03	0.00	−0.04	−0.01	2.9	−0.18	−30.60	−1.27	−42.25	−7.29
Oil and fats	1.0	0.00	−0.13	−0.06	−0.18	−0.04	3.0	0.00	−3.65	−2.31	−5.95	−1.73
Fruit and vegetables	6.2	0.00	−2.92	−0.04	−2.96	−0.88	5.6	0.00	−42.47	−0.71	−42.82	−12.85
Fruit and vegetable preparations	2.9	0.00	−1.96	0.22	−1.66	−0.37	3.1	0.00	−30.86	3.58	−25.88	−6.17
Coffee, spices, cocoa and sugar	0.4	0.00	−0.17	0.03	−0.14	−0.06	7.5	0.47	−31.29	9.01	−20.86	−15.17
Tobacco	0.0	0.00	0.00	0.00	0.00	0.00	0.8	1.43	−0.56	1.63	−0.36	3.78
Non-alcoholic beverages	0.2	0.00	−0.05	0.00	−0.05	−0.01	2.5	0.00	−5.32	0.32	−5.00	−0.97
Wines	0.1	0.00	0.00	0.01	0.01	0.00	16.0	0.00	10.14	63.85	67.91	1.01
Other alcoholic beverages	0.1	0.00	−0.01	−0.08	−0.10	0.00	9.8	0.00	−19.92	−174.96	−188.03	0.62
Other preparations	12.6	0.18	−1.62	0.40	−1.36	−0.48	8.0	1.01	−13.14	4.04	−10.11	−6.57
Other products	0.6	−0.06	−0.10	−0.09	−0.13	−0.06	0.8	−1.52	−2.32	−2.27	−3.13	−1.36
Total	*100*	*−11.11*	*−123.51*	*−19.70*	*−173.38*	*−60.25*	*100*	*−20.42*	*−673.61*	*−156.32*	*−1,000.24*	*−223.32*
		Exports (sales) to the United Kingdom										
Product group	Share	S1	S2	S3	S4	S5	Share	S1	S2	S3	S4	S5
Live animals	2.1	0.89	−0.03	0.98	0.00	0.69	0.9	7.41	−0.18	8.13	0.00	5.79
Meat and meat products	36.9	−11.50	−47.71	−19.83	−60.15	−21.37	3.2	−19.69	−81.49	−33.86	−102.68	−36.51
Dairy products	9.2	−0.68	−7.27	−0.73	−8.74	−1.23	12.2	−17.79	−190.14	−19.08	−229.10	−32.44
Fish and seafood products	3.6	−1.49	−6.32	−1.12	−6.01	−1.31	1.6	−12.67	−53.52	−9.50	−50.93	−11.15
Cereals and cereal products	21.3	0.00	−15.99	−1.66	−17.54	−3.01	12.7	0.00	−187.53	−19.54	−205.73	−35.32
Grain processing products	0.0	0.00	−0.08	−0.01	−0.09	−0.02	2.0	−0.59	−64.70	−5.68	−77.77	−14.73
Oil and fats	1.4	0.00	−0.75	−0.14	−0.87	−0.11	4.0	0.00	−43.87	−8.20	−51.03	−6.30
Fruit and vegetables	7.7	0.00	−4.69	0.01	−4.69	−1.30	6.4	0.00	−78.27	0.13	−78.27	−21.74
Fruit and vegetable preparations	6.7	0.00	−6.54	0.51	−5.94	−1.05	3.0	0.00	−56.88	4.50	−51.64	−9.16
Coffee, spices, cocoa and sugar	0.2	0.00	−0.15	0.01	−0.14	−0.04	9.1	2.81	−148.30	9.58	−141.18	−37.88
Tobacco	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.17	−0.40	0.16	−0.41	0.32
Non-alcoholic beverages	0.2	0.00	−0.06	0.00	−0.06	0.00	2.2	0.00	−13.57	0.03	−13.59	−1.09
Wines	0.1	0.00	−0.01	0.00	0.00	0.00	26.2	0.00	−52.78	22.77	−24.15	−5.52
Other alcoholic beverages	0.1	0.00	−0.04	0.04	0.00	0.00	7.5	0.00	−56.76	49.42	−5.80	4.71
Other preparations	9.9	0.32	−3.01	0.03	−3.32	−0.55	8.6	5.47	−51.94	0.46	−57.36	−9.58
Other products	0.7	−0.11	−0.18	−0.14	−0.21	−0.11	0.5	−1.77	−2.82	−2.18	−3.26	−1.64
Total	*100*	*−12.57*	*−92.80*	*−22.06*	*−107.77*	*−29.41*	*100*	*−36.64*	*−1,083.14*	*−2.87*	*−1,092.90*	*−212.24*
		Exports (sales) to the EU (excluding the UK and France)										
Product group	Share	S1	S2	S3	S4	S5	Share	S1	S2	S3	S4	S5
Live animals	2.8	−0.51	−0.24	−0.77	−0.63	−0.74	4.7	−11.56	−5.78	−20.23	−20.05	−18.61
Meat and meat products	39.2	5.65	−27.75	3.60	−51.74	−20.04	6.7	14.85	−89.62	8.45	−161.31	−61.96
Dairy products	18.9	0.87	2.18	1.69	−0.95	0.37	12.3	9.02	15.67	18.05	−24.69	2.85
Fish and seafood products	9.4	1.87	7.36	1.60	7.11	1.56	2.9	9.52	37.31	8.18	36.08	7.96
Cereals and cereal products	5.4	0.00	0.51	0.12	0.46	0.01	22.4	0.00	28.42	7.75	23.26	−0.86
Grain processing products	0.0	0.00	0.01	0.00	0.00	0.00	3.4	0.40	1.06	1.58	−6.99	−5.01
Oil and fats	1.2	0.00	0.18	0.02	0.19	0.00	3.8	0.00	8.84	0.88	9.43	0.00
Fruit and vegetables	7.6	0.00	1.82	−0.08	1.73	0.38	7.0	0.00	22.73	−1.08	21.38	4.33
Fruit and vegetable preparations	2.8	0.00	1.18	−0.12	1.02	0.07	3.7	0.00	25.81	−2.44	22.23	1.15
Coffee, spices, cocoa and sugar	0.5	0.00	0.25	0.01	0.27	0.01	9.0	−1.38	62.49	4.14	69.05	2.42
Tobacco	0.0	0.00	0.00	0.00	0.00	0.00	0.9	−0.07	2.04	0.07	2.22	1.02
Non-alcoholic beverages	0.2	0.00	0.09	0.00	0.10	0.00	2.4	0.00	11.94	0.46	12.21	−0.55
Wines	0.0	0.00	0.00	0.00	0.00	0.00	8.2	0.00	16.67	18.55	36.17	−0.31
Other alcoholic beverages	0.0	0.00	0.02	0.00	0.02	0.00	4.1	0.00	52.81	2.66	52.18	0.63
Other preparations	11.8	−0.18	0.95	−0.03	1.11	−0.67	7.8	−1.80	10.77	−0.30	12.57	−8.08
Other products	0.3	0.00	0.01	0.00	0.00	0.01	0.7	0.14	0.35	−0.23	−0.06	0.20
Total	*100*	*7.70*	*−13.42*	*6.04*	*−41.30*	*−19.05*	*100*	*19.13*	*201.51*	*46.50*	*83.65*	*−74.84*

Table A2 – *(contd.)*

		Brittany					Rest of France				
		Exports (sales) to the rest of the world									
Product group	Share	S1	S2	S3	S4	S5	Share	S1	S2	S3	S4	S5
Live animals	4.3	−0.07	0.30	−0.79	−0.54	0.08	1.0	−0.13	1.31	−3.45	−2.75	0.43
Meat and meat products	42.4	8.21	39.49	25.04	53.16	11.12	3.8	13.17	62.38	38.33	81.93	17.54
Dairy products	23.5	0.07	6.71	0.09	7.47	1.52	7.7	0.28	40.18	−0.42	42.85	10.11
Fish and seafood products	2.8	0.26	1.28	0.08	1.14	0.25	1.5	2.32	11.64	0.61	10.33	2.32
Cereals and cereal products	5.0	0.00	0.45	0.08	0.45	0.50	9.6	0.00	14.27	2.61	13.74	17.40
Grain processing products	0.0	0.00	0.03	0.00	0.04	0.01	2.0	0.11	28.88	2.60	35.99	9.74
Oil and fats	0.5	0.00	0.06	0.00	0.06	0.01	1.0	0.00	2.42	−0.06	2.28	0.44
Fruit and vegetables	2.4	0.00	1.11	0.02	1.16	0.35	2.4	0.00	18.66	0.35	19.36	6.10
Fruit and vegetable preparations	1.7	0.00	1.11	−0.02	1.14	0.24	2.0	0.00	23.95	−0.47	24.52	5.20
Coffee, spices, cocoa and sugar	0.2	0.00	0.06	0.00	0.05	0.03	3.8	−0.35	17.41	−1.45	16.65	8.15
Tobacco	0.1	0.00	0.00	0.00	0.00	0.00	0.9	0.10	0.99	0.25	1.15	−0.18
Non-alcoholic beverages	0.1	0.00	0.01	0.00	0.01	0.00	3.1	0.00	4.96	−0.17	5.07	1.45
Wines	0.2	0.00	0.02	0.01	0.02	0.00	29.0	0.00	55.29	19.48	58.98	8.95
Other alcoholic beverages	0.2	0.00	−0.02	−0.14	−0.16	0.00	22.9	0.00	−51.21	−323.92	−360.97	−8.33
Other preparations	15.4	−0.12	1.46	0.39	1.99	0.85	8.2	−1.04	14.17	3.58	19.10	8.06
Other products	1.2	0.09	0.14	0.12	0.18	0.08	1.0	1.29	1.97	1.69	2.42	1.17
Total	*100*	*8.44*	*52.22*	*24.88*	*66.17*	*15.05*	*100*	*15.76*	*247.27*	*−260.42*	*−29.36*	*88.55*
		Exports (sales) to Brittany										
Product group	Share	S1	S2	S3	S4	S5	Share	S1	S2	S3	S4	S5
Live animals	6.6	−0.08	−0.04	−0.12	−0.10	−0.13	5.5	−0.32	−0.15	−0.50	−0.50	−0.51
Meat and meat products	30.5	0.32	−1.51	0.20	−2.85	−1.08	11.7	0.61	−3.23	0.34	−5.95	−2.26
Dairy products	31.5	0.10	0.23	0.19	−0.16	0.04	26.4	0.41	0.82	0.84	−1.14	0.11
Fish and seafood products	7.9	0.12	0.48	0.11	0.47	0.10	4.5	0.35	1.37	0.33	1.34	0.30
Cereals and cereal products	9.3	0.00	0.05	0.01	0.04	0.00	20.7	0.00	0.44	0.14	0.30	−0.07
Grain processing products	0.0	0.00	0.00	0.00	0.00	0.00	3.7	0.01	0.00	0.04	−0.18	−0.13
Oil and fats	0.8	0.00	0.01	0.00	0.01	0.00	5.2	0.00	0.28	0.05	0.32	0.00
Fruit and vegetables	2.9	0.00	0.05	0.00	0.05	0.01	1.7	0.00	0.12	0.00	0.12	0.02
Fruit and vegetable preparations	2.7	0.00	0.09	−0.01	0.08	0.00	3.8	0.00	0.64	−0.05	0.56	0.03
Coffee, spices, cocoa and sugar	0.1	0.00	0.00	0.00	0.00	0.00	3.0	−0.01	0.52	0.03	0.57	0.02
Tobacco	0.0	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00
Non-alcoholic beverages	0.0	0.00	0.00	0.00	0.00	0.00	0.6	0.00	0.05	0.00	0.06	0.00
Wines	0.0	0.00	0.00	0.00	0.00	0.00	0.7	0.00	0.02	0.04	0.06	0.00
Other alcoholic beverages	0.0	0.00	0.00	0.00	0.00	0.00	1.8	0.00	0.55	0.12	0.64	0.01
Other preparations	7.3	−0.01	0.04	0.00	0.04	−0.03	10.3	−0.05	0.28	−0.02	0.32	−0.23
Other products	0.4	0.00	0.00	0.00	0.00	0.00	0.4	0.01	0.01	0.00	0.01	0.01
Total	*100*	*0.46*	*−0.59*	*0.38*	*−2.41*	*−1.08*	*100*	*1.01*	*1.72*	*1.36*	*−3.48*	*−2.70*
		Exports (sales) to the Rest of France										
Product group	Share	S1	S2	S3	S4	S5	Share	S1	S2	S3	S4	S5
Live animals	3.0	−0.37	−0.17	−0.52	−0.39	−0.52	1.2	−0.91	−0.40	−1.36	−1.21	−1.38
Meat and meat products	50.0	3.78	−23.47	1.69	−42.05	−15.91	4.7	2.32	−16.53	0.92	−29.11	−10.96
Dairy products	19.9	0.54	1.37	1.06	−0.54	0.34	10.2	1.91	4.20	3.82	−3.92	0.86
Fish and seafood products	4.7	0.61	2.38	0.56	2.33	0.52	2.6	2.21	8.61	2.06	8.47	1.87
Cereals and cereal products	4.0	0.00	0.18	0.05	0.15	−0.01	22.7	0.00	5.32	1.70	3.62	−0.85
Grain processing products	0.0	0.00	0.00	0.00	0.00	0.00	2.0	0.06	−0.12	0.23	−1.27	−0.77
Oil and fats	0.7	0.00	0.06	0.01	0.07	0.00	2.0	0.00	1.12	0.13	1.23	0.00
Fruit and vegetables	3.4	0.00	0.43	−0.02	0.41	0.09	7.7	0.00	4.99	−0.29	4.77	0.94
Fruit and vegetable preparations	2.7	0.00	0.69	−0.06	0.60	0.04	5.1	0.00	8.88	−0.72	7.87	0.38
Coffee, spices, cocoa and sugar	0.4	0.00	0.10	0.01	0.11	0.01	7.7	−0.29	13.66	1.15	15.39	0.65
Tobacco	0.0	0.00	0.00	0.00	0.00	0.00	2.0	−0.13	1.34	−0.06	1.45	0.47
Non-alcoholic beverages	0.1	0.00	0.02	0.00	0.02	0.00	2.1	0.00	2.10	0.16	2.25	0.04
Wines	0.0	0.00	0.00	0.00	0.00	0.00	7.8	0.00	2.91	4.37	7.36	−0.07
Other alcoholic beverages	0.0	0.00	0.02	0.00	0.03	0.00	14.3	0.00	49.49	9.39	55.93	0.67
Other preparations	10.6	−0.10	0.57	−0.03	0.64	−0.35	6.8	−0.44	2.54	−0.13	2.86	−1.65
Other products	0.3	0.01	0.02	0.01	0.01	0.01	1.4	0.24	0.42	0.11	0.28	0.25
Total	*100*	*4.48*	*−17.79*	*2.76*	*−38.61*	*−15.78*	*100*	*4.96*	*88.56*	*21.49*	*75.97*	*−9.55*

Notes: The effects of the five Brexit scenarios described in Table 1. In scenario S1, exports of live animals from Brittany to the United Kingdom would have increased by 0.89 million euro.

N° 539 (2023)

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N° 530-31 (2022) – VARIA

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Economie et Statistique / Economics and Statistics

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Economie et Statistique / Economics and Statistics publishes articles covering any micro- or macro- economic or sociological topic, either using data from public statistics or other sources. Particular attention is paid to rigor in the statistical approach and clarity in the concepts and analyses. In order to meet the journal aims, the main conclusions of the articles, as well as possible limitations, should be written to be accessible to an audience not necessarily specialist of the topic.

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