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Policy Uncertainty and Inventor Mobility

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Abstract

We follow the migration patterns of European inventors and find evidence of a novel emigration determinant: policy uncertainty. We find that policy uncertainty raises the rate of inventor emigration by a notable magnitude. With a one standard deviation in the policy uncertainty of the home country, relative to the possible destination countries, the rate of inventor emigration increases by nearly 40%. Migrating inventors are subsequently exposed to lower levels of policy uncertainty in the destination country emphasising that uncertainty motivated the move. We conclude that these effects may have strong welfare implications at the aggregate level.

Keywords: Out-Migration, Brain Drain, Uncertainty, Inventors

JEL codes: J61, O15

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1 Introduction

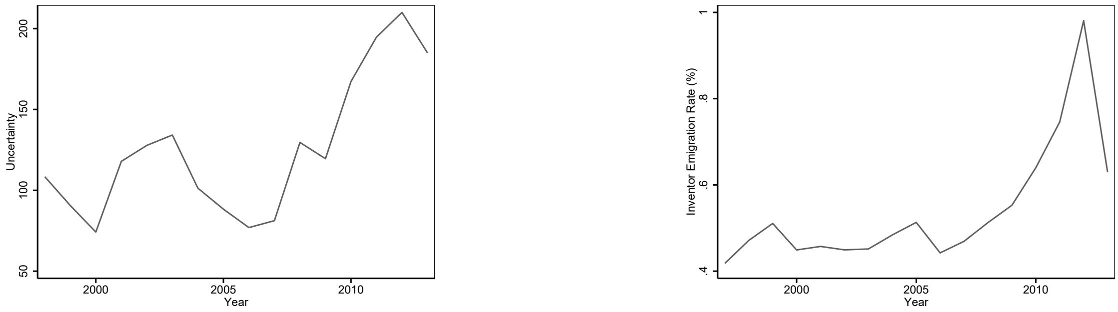
In this paper we offer novel evidence that policy uncertainty is a determinant of out migration through our analysis of inventor migration in Europe. At the aggregate level, both policy uncertainty and inventor emigration have notably increased in developed countries. The below figures (cf. Figure 1) map their respective paths over the past few decades.

These common trends motivate us to further examine a risk preference mechanism of emigration noted in Gibson and McKenzie (2011b). In their survey of high skilled individuals from Oceania they cast doubt on the purely income maximisation framework of migration instead finding preferences - notably on risk - to be a stronger determinant. This adds to the prior work of Jaeger et al. (2010) who find risk averse individuals to be less likely to emigrate.[1] In their setup potential emigres are deterred by a higher spread of payoffs in the foreign country creating a forecasting difficulty in emigration relative to staying at home.

Our approach differs in two key respects. First, we consider the probability of various payoffs to be unknown to the inventor at the point of the emigration decision. Therefore the risk faced in emigration would be better captured as uncertainty, per the seminal distinction of Knight (1921). Second, the issue of payoffs being more difficult to determine in the case of migration compared to staying at home, noted by Jaeger et al. (2010), is captured by a baseline level of uncertainty that is present for all inventors in our setup. This generally refers to uncertainty surrounding the migration process. The primary contribution of our framework is to introduce the relative policy uncertainty at home compared to abroad. This then either exacerbates the problem when uncertainty is higher abroad or mitigates the problem, by introducing the same issue in the home country, when uncertainty is higher at home. This allows us to test the role of uncertainty in the emigration decision.

[1] Tunali (2000) also considered emigration to be a fundamentally risky process with highly skewed payoffs which are negative for the median emigre.

Figure 1: Macro Trends in Europe



(a) Uncertainty Trend

(b) Inventor Emigration Trend

Figure (a) illustrates the policy uncertainty level in Europe between 1997 and 2013. The policy uncertainty level is the Economic Policy Uncertainty for Europe (Baker et al. (2016)). Figure (b) Shows the inventor emigration rate for Europe between 1993 and 2013. Inventor Emigration is calculated as the number of departing inventors in a given year (summed over all countries) over the total stock of inventors in the country that year (again summed over all countries). The countries considered are UK, France, Germany, Italy, Belgium, Sweden, Spain, Ireland, Greece and Croatia.

Our theory can be reconciled with the classical real options theory of Dixit and Pindyck (1994). Under real options theory an increase in uncertainty raises the value of waiting, delaying economic activity.[2] In this case we are concerned with the relative uncertainty between the home and target country and the emigration decisions of inventors. A higher relative uncertainty in the target country leads to an increased value of waiting. Our setting looks at the relative uncertainty between the home and target countries. Here, a higher relative uncertainty at home mitigates the baseline uncertainty in the migration process as the issues of uncertainty are now prevalent at home. Thereby increasing emigration. The different angle through which we view the process makes our prediction differ from that of a real options framework in the respect that we expect an acceleration of behaviour under uncertainty rather than a delay.

[2]Typically investment into fixed assets. However, in recent years real options theory has been shown to apply to other forms of economic behaviour under uncertainty. For instance, decreased trade flows (Novy and Taylor, 2020) and reduced hiring (Baker et al., 2016).

We illustrate the nuance of our approach through a simple stylised representation of the inventor emigration decision. This illustrates how relative policy uncertainty influences emigration while reconciling our theory with other migration determinants frequently discussed in the literature.

In order to estimate the resultant inventor emigration equation we construct a novel inventor career panel. From this we can extract observable time varying characteristics of individual inventors and employ inventor level fixed effects to minimise concerns around selection bias. We obtain country level variation in uncertainty through constructing a relative uncertainty measure which uses the economic policy uncertainty index (Baker et al., 2016) of the origin and destination countries as an input. Other time varying characteristics of the origin and destination countries which could likewise influence the emigration decision are conditioned on through a country control vector. With all this we can estimate inventor response to uncertainty through their migration decisions and, interestingly, whether they re-locate to a destination with lower uncertainty.

Across all our initial estimations we find policy uncertainty increases the rate of inventor emigration. The effect is substantial. In our most basic specification we find c.20% increase in the fraction of emigrating inventors for a one standard deviation increase in relative policy uncertainty. This rises to c.26% when all controls are included. Inventors who do move are exposed to lower policy uncertainty in the subsequent years. Further evidencing that policy uncertainty was a motivating factor in the move.

In order to circumvent endogeniety concerns we employ instrumental variable regressions utilizing the timing of close elections as a instrument for relative policy uncertainty. In our Two-Stage Least Squares estimations our coefficients increase notably. The fraction of emigrating inventors is now c.40% greater than the baseline. Providing further evidence of a relationship between policy uncertainty and emigration.

In all, our results offer novel evidence of a new determinant of emigration: policy uncertainty. We show our results are robust to the inclusion of proxy variables for other key determinants discussed in the migration literature, notably international networks and institutional factors.[3] Our results remain impactful at the aggregate level. In a simple illustrative exercise we show that a one standard deviation rise in uncertainty could lead to a significant amount of lost invention in the subsequent decade due to enhanced inventor outflows.

While our setting comprises solely of inventors, there is no clear reason to believe inventors are unique in their migration responses to policy uncertainty, the results are credibly inferable to the general population of high-skilled labour. This all suggests the role of policy uncertainty as an emigration determinant is a fruitful avenue for future research.

The remainder of the paper is structured as follows. Section II motivates our interest through the development of a toy model intended to guide our analysis. Section III describes the data and their relation to the components of the theoretical framework. Section IV details our empirical estimations, identification concerns, results and extensions. Section V concludes.

2 Conceptual Setting

In this section we walk through a simple stylized representation of the inventor emigration decision. We offer a static two country toy model which centers around an inventor deciding whether to remain in their home country or emigrate to the foreign country. The inventor makes the decision by considering the relative utility obtainable between the two countries and the cost of emigration.

[3] Cooray and Schneider (2016) evidence that corruption increases the likelihood of high skilled emigration. Beine et al. (2011) and Hanson and McIntosh (2010) both emphasise the importance of diasporas in explaining variation in migrant flows.

2.1 Emigration Utility Equation

Inventors can conduct their inventive activity in one of two countries. They can remain in their current country or emigrate to the foreign country.[4] Inventors will emigrate when foreign utility exceeds home utility by more than the cost of emigration. The inventor's emigration decision is illustrated below.

$$U^* = U_1 - U_2 - c \tag{1}$$

$$Emigrate = \begin{cases} 1, & U^* > 0 \\ 0, & U^* \leq 0 \end{cases}$$

2.2 Utility

An inventor's utility is rising in the income (I) and the quality of life (Q)[5] of their country of residence according to a an unknown function f. Intuitively, income is repeatedly found to be a key determinant in migration decisions (Kennan and Walker, 2011). This seems to be especially true for inventors, who have been shown to increase mobility when exposed to higher income tax brackets (Akcigit et al., 2016).

$$U = f(I, Q) \tag{2}$$

[4]The foreign country is indicated by subscript 1 and the home country by subscript 2. This remains the case throughout.

[5]This can be thought to reflect factors such as cost of living, crime rates, child care and leisure time.

We introduce uncertainty (σ) into the model in the context of the unquantifiable risk surrounding the emigration process.[6] This general migration uncertainty is present for all inventors. The role of uncertainty in the migration decision can then rise or fall depending on the relative uncertainty between the origin (σ_2) and destination country (σ_1), where relative uncertainty is defined as $\widetilde{\sigma} = \frac{\sigma_2}{\sigma_1}$. More uncertainty in the foreign country would add to the existing uncertainty surrounding the migration process. Thereby, lowering the utility of emigration. A higher uncertainty in the home country would mitigate the importance of the baseline level of uncertainty in the migration process. Thereby, increasing the utility of emigration. Inventors who previously would have emigrated but could not due to finding the process excessively uncertain would then emigrate.

Allowing the utility components to differ between the two countries and plugging into our main equation leads to the expansion shown below.

$$U^* = f(I_1, Q_1, \sigma_1) - f(I_2, Q_2, \sigma_2) - c \tag{3}$$

$$dU^*/dI_1 > 0,\ dU^*/dI_2 < 0\ dU^*/dQ_1 > 0,\ dU^*/dQ_2 < 0\ dU^*/d\sigma_1 < 0\ dU^*/d\sigma_2 > 0$$

Taking income and quality of life to also be relative[7] between the two countries and simplifying yields the following.

$$U^* = f(\widetilde{I}, \widetilde{Q}, \widetilde{\sigma}) - c \tag{4}$$

$$dU^*/d\widetilde{I} < 0,\ dU^*/d\widetilde{Q} < 0,\ dU^*/d\widetilde{\sigma} > 0$$

[6] Knight (1921) distinguished between risk and uncertainty through whether the probabilities of future events are known (risk) or unknown (uncertainty). Bloom (2014) notes that in recent years uncertainty proxies tend to capture some mixture of uncertainty and risk. For the study of inventor emigration we assume that the inventor does not (fully) know the probabilities of the payoffs of emigration.

[7] For the relative income between the home and foreign country $\widetilde{I} = \frac{I_2}{I_1}$ and for the relative quality of life $\widetilde{Q} = \frac{Q_2}{Q_1}$

Emigration utility is decreasing when either income or the quality of life is relatively higher at home. In contrast, a relatively higher uncertainty in the home country acts by mitigating the perceived uncertainty around the migration process, as uncertainty becomes more prevalent at home, and increases the emigration utility.

2.3 Cost of Emigration

Inventor's face a one-off cost of emigration. The cost can be decomposed as an unknown function (g) of country specific factors (ρ), irreversible investments (W) made in the home country, and the individual ability of the inventor (A). Equation (5) illustrates the various factors.

Country specific factors broadly encompass the implicit costs of the visa process, learning any new languages and cultural adaptation. Irreversible investments reflect the loss of any investments made in the home country which cannot be transported to the destination country (such as tacit knowledge on doing business in the home country) or investments which can only be salvaged in the destination country through payment of an additional cost. Those of higher education levels are observed to have higher emigration rates at the aggregate level (Gibson and McKenzie, 2011a). This likely reflects the greater availability of opportunities abroad for the higher skilled, an easier time navigating the visa process,[8] or being better suited to cultural adaptations. We include ability to capture this.

$$c = g(\rho, W, A) \tag{5}$$

Emigration utility is decreasing in the cost of emigration (showed in full above). Taking the first order conditions of the emigration utility equation with respect to our three cost components yields the following.

$$dU^*/d\rho < 0,\ dU^*/dW < 0,\ dU^*/dA > 0$$

[8]Beine et al. (2011) note that individuals of a higher human capital often benefit from selective immigration policies.

Emigration utility is falling in country specific factors, such as the general attitude to immigration in the country, and in irreversible investments made by the inventor in the home country. It is rising in ability. This reflects that inventors of higher ability may have less trouble with the visa process, cultural adaptations and embedding themselves in new innovative networks.

Introducing the new elements into the emigration utility equation leads to our final specification (equation 6).

$$U^* = f(\widetilde{I}, \widetilde{Q}, \widetilde{\sigma}) - g(\rho, W, A) \tag{6}$$

3 Data

Estimating our equation of interest (equation 6) depends on our ability to suitably measure the various components or construct adequate proxy variables. This requires data on inventor specific characteristics and on country level factors. We collect this data for a set of developed European countries for the period 1997-2013. Descriptive Statistics are shown in Table 1.

3.1 Country Level

A wide array of measures of uncertainty have been used in the prior art. For instance, Bloom and Van Reenen (2002) use stock market volatility and several papers look to exploit natural experiments as a source of uncertainty. We require our choice of uncertainty measure to be impactful enough to individual inventors to feasibly influence their emigration decision, and have enough cross-country variation to identify any effects. Inventors do not need to be located in a given country to own companies listed on its national stock exchange so the resulting uncertainty is unsuitable for study of migration. Natural experiments could be considered but few occur in our sample and such events tend to have mechanisms of affecting economic behavior beyond uncertainty. Natural disasters for instance may lead to forced displacement and/or infrastructure damage. Any uptakes in out migration in response could be the result of legitimate safety concerns rather than uncertainty.[9]

We opt for the Economic Policy Uncertainty index (Baker et al., 2016). A country level text based index which rises based on the frequency of combinations of uncertainty suggesting terms appearing within the major newspapers of the given country.[10] It is a continuous measure, which allows it to quantify large bouts of uncertainty in a manner that a dummy variable such as natural disasters couldn't, and has significant variation in both the cross sectional and time series dimensions. In addition, the index is highly general. It has been shown to correlate with several other uncertainty measures, capturing economic or political uncertainty, such as the content of the Beige Book [11] and the aforementioned stock market volatility (Baker et al., 2016).

In our setting, we wish to capture the relative uncertainty between the home and destination countries. We arrive at our relative uncertainty variable ($REPU$) through dividing the policy uncertainty of the home country with that of the average policy uncertainty of the set of destination countries.

$$REPU_{j,-j,t} = EPU_{j,t} / \frac{\sum_{-j=1}^{n} EPU{-j,t}}{n} \tag{7}$$

[9]To some extent all uncertainty measures could be argued to capture safety concerns. In order to circumvent any such issue influencing our results, we include a crime control in all specifications and later show our results to be robust to the inclusion of a safety based index.

[10]The terms are "Uncertainty", "Economic" and a policy term. The latter differs by country but typically includes the name of the central bank, legislation, regulation and budget. See Baker et al. (2016) for details on the index. See Appendix F for the specific sources of the country based indices used to form our sample.

[11]A twice quarterly economic overview based on concerns expressed to the regional banks of the United States federal reserve.

Therefore, $-j$, can be thought to reflect all possible destination countries, $-j \neq j$. In the hypothetical case that the home country has equal policy uncertainty to the group of foreign countries, $REPU = 1$. Likewise, if the home country has higher policy uncertainty then $REPU > 1$. $REPU < 1$ reflects instances where the home country has relatively lower uncertainty than the target countries. Including a relative uncertainty measure as our main regressor allows us to directly test our theory that higher relative uncertainty at home increases the rate of inventor emigration. Precise details on the identification of our relative uncertainty coefficient are provided in the next section. We can see from Table 1 that the variable has a mean of close to 1, as expected.

Our country control vector includes factors of the host and possible destination countries which could feasibly influence the migration decision. Or in relation to our emigration utility equation (Eq.6) these are intended to control for the influence of income, quality of life and country specific factors. In the case of income we face the limitation that our inventor level data unfortunately does not allow us to identify the exact income of each inventor. Our second choice measure would be to construct a more general inventor income measure for country-year pairs using occupational wage data on inventive professions. However, occupational wage data is limited for our sample scope and time frame. Instead we use the income level of the country, GDP per capita, as a proxy. Much of the variation that would be present in inventor level data is clearly lost here. However under the assumption that inventors will earn more in countries with higher income levels we consider it suitable as a control for income. Our income measure, and all other country controls, are treated to create relative measures in a manner analogous to equation 7.

The other variables included in our country control vector are the crime rate, institutional quality, the inflation rate and the employment rate. Details on the data sources used to construct our control variables are given in Appendix F. It should be noted that our country control vector omits some previously discussed emigration determinants from consideration. In particular, the exchange rate, and variables for a shared language or colonial past are omitted. With each being highly unlikely to explain variation in emigration in our specific setting.[12]

3.2 Inventor Level

We observe the careers of inventors through published patents at the European Patent Office. From the raw patent data, we construct an inventor career panel through name disambiguation. This uses a text mining algorithm based on names and addresses of inventors, patent applications, and invention characteristics (such as technology fields and citation patterns) (Doherr, 2021).[13] We start with 2,597,650 inventor careers. Mobility across borders is detected through a change in country code in the inventor's address on the patent. Instances of "temporary"[14] inventor mobility are dealt with as follows. We take a time window of 4 years prior to any potential migration event and collect all residential countries designated by patents in this time frame. If any such country appears as the destination within the subsequent 4 year window the event is defined as temporary and not as out migration.

[12] Almost all of our sample use the Euro (with the exception of the UK and Sweden). Beyond the UK and Ireland, none of our sample share a language and none have held significant colonial interests in the other.

[13] See Doherr (2021) for more details.

[14] Inventors located within multinational companies can be temporarily relocated for projects in other countries.

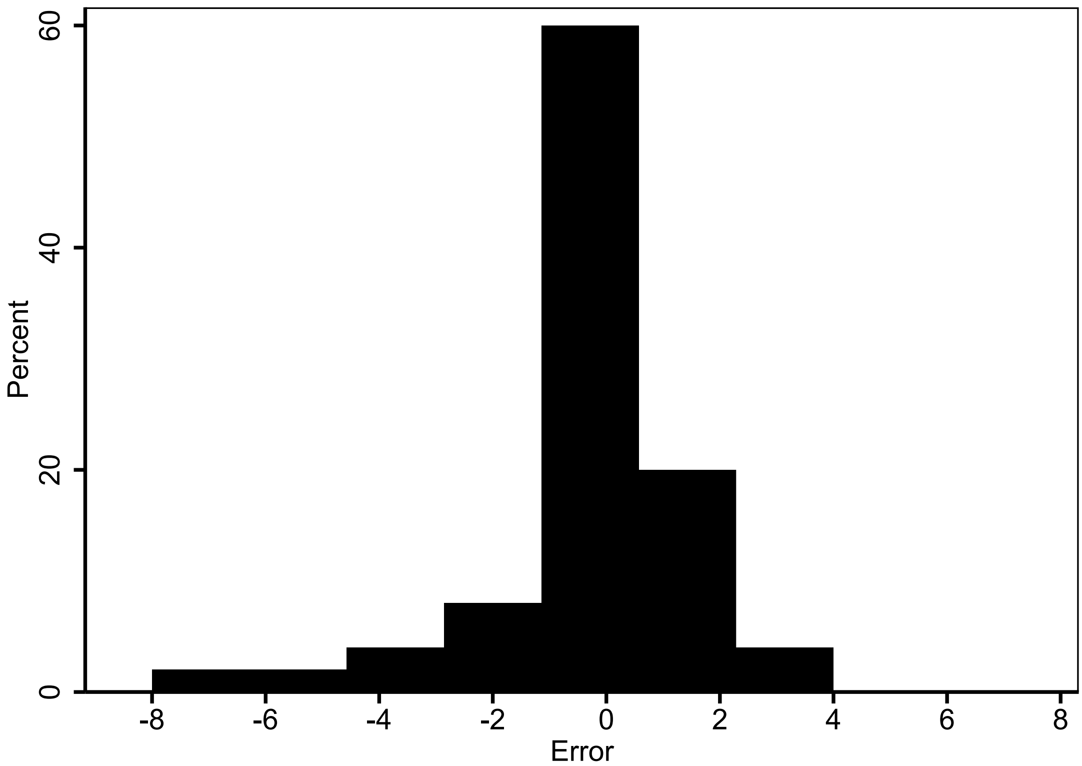
Removing the 14,402 inventors who at some point partake in such behaviour reduces our sample to 2,583,248 inventor careers. We next isolate the scope of the resultant career panel to countries for which we have policy uncertainty data. This reduces our sample to 716,055 inventor careers.

As we only observe inventors at the points throughout their career in which they file a patent application, we are forced to make an assumption with regards to the timing of their move. We define an inventor to have migrated in the year prior to the patent registering the country switch. For 38.5% of the emigrating inventors in our sample we can confirm the assumption as the migration occurred between patents with consecutive priority years. For the remainder the gap between patents is longer so the emigration timing is assumed.

We conduct a validity check on our assumption through searching for a small random sub-sample of emigrating inventors on Linkedin. Linkedin can overcome the issue of the timing of patents (inventors who patent sporadically may update their Linkedin profiles more consistently) and has been shown to be a more accurate source of information on inventor careers than patent data (Ge et al., 2016). The validity check shows an error margin by comparing our assumption to the year an emigration is registered by a location change on the inventors Linkedin. When an inventor emigration is defined in the same year by our assumption and their Linkedin profiles we assign an error of 0. When an inventor emigrates a year earlier on Linkedin than our assumption, we assign an error of -1. And when an inventor emigrates a year later on Linkedin than our assumption, we assign an error of +1. The resulting error distribution is shown below (figure 2).

We see that the distribution is centered close to zero with few observations in the tails. The exact center is at -0.5 suggesting a slight average error in our assumption, but that nevertheless our assumption is the best of the possible choices. With defining an inventor to have moved 2 years prior to the patent in the new country being the next best option.

Figure 2: Error Distribution



The figure shows the distribution of errors when our emigration year assumption is compared to the emigration year listed on the inventor's Linkedin profile. The distribution is composed of 50 random inventors who both emigrate in our sample and have a listed change in employment between the same two countries on their linkedin profile.

We conduct a robustness test where the emigration year is set to 2 years prior to the patent registering a country switch for the 61.5% of emigrating inventors who do not emigrate between consecutive patent priority years. This does not significantly alter any of our main results. The replications with an alternate move timing assumption are shown in Appendix C.

The resultant inventor career panel provides us with a wealth of information for each inventor i in country j for years t. We utilise this to build a vector of inventor characteristics. We condition on these characteristics to protect against the likely scenario that observable inventor characteristics are associated with their likelihood of emigration. In particular, components of the cost of emigration (Eq. 5), inventor specific ability and inventor specific investments made in the home country, may be approximated by citations and the patent stock, respectively.

The patent stock and patent citations are used to measure the productivity of the individual inventor. Patent citations in particular have been used as a measure of the value of an invention (Trajtenberg, 1990). This motivates the assumption that inventors with higher ability will produce higher value inventions. The cumulative nature of patent citations suggest that inventors continually improve on their innate talents, without regressing, albeit at different rates. Even though we also employ inventor fixed effects in our estimation which account for time constant ability, the ability of an individual will vary with the breadth and depth of their experience. The individuals' patent stock and citations are thus included to reflect a time-varying measure of ability.

We also include a measure for foreign networks. This captures the influence that an existing infrastructure of foreign collaborators may have in the inventor emigration decision. Existing literature on diasporas (Beine et al., 2011; Hanson and McIntosh, 2010) suggest that an existing network abroad could increase the likelihood of emigration. Perhaps through lowering the cost of emigration. Given we are concerned with prior collaborators and not diasporas, the predictions are unlikely to hold. However, it seems plausible that those with existing projects in a destination country could face lower costs of emigration. We generate a dummy variable equal to 1 if an inventor has previously jointly patented with another inventor in a foreign country; zero otherwise. Less than 7.5% of the inventors in our sample have some form of foreign network.

4 Econometric Estimation

We model the potential emigration of inventor i from their home country j to destination $-j$ in year t as shown in equation (8). We estimate the model using the within fixed-effects estimator.[15]

[15] Given our binary dependent variable, we also estimate our model using a conditional fixed-effects logit estimator.

Table 1: Descriptive Statistics

	Mean	SD	Median	Min	Max	N
Leaving	0.005	0.07	0.000	0.000	1.000	1,746,661
Relative Policy Uncertainty	1.093	0.22	1.094	0.303	1.758	1,746,661
Citations Per Patent	1.640	1.33	1.061	1.000	188.000	1,746,661
Patent Stock	2.404	3.25	1.337	0.006	159.656	1,746,661
Foreign Collaborators	0.075	0.26	0.000	0.000	1.000	1,746,661

The upper table offers summary statistics. Our uncertainty measure is calculated as above. Citations per patent is the inventors' cumulative number of patents divided by their accumulated citations at the given point in time. The patent stock is a relative variable calculated analogously to the country level variables above. The lower table shows the number of inventors registered to each country in our sample. The first showing inventor-year observations and the latter the number of inventor careers in our sample.

Country	Inventor-year	Inventor Careers
Belgium	30726	16249
Germany	895317	305958
Croatia	610	420
France	335640	153943
United Kingdom	195167	98702
Italy	142777	59727
Spain	39989	25794
Ireland	10883	6970
Sweden	92832	46298
Greece	2720	1994
Total	1746661	716055

$$LEAVE_{i,j,-j,t} = \alpha_i + \delta REPU_{i,j,-j,t} + \beta X_{i,t} + \beta X_{j,-j,t} + \gamma_t + \epsilon_{i,j,-j,t}, \tag{8}$$

The out migration dummy is our dependent variable. It equals 1 when inventor i emigrates from country j to destination $-j$ at time t. The previous section illustrated (equation 7) that our policy uncertainty variable, REPU, is relative, such that it quantifies the policy uncertainty in country j relative to the set of possible destination countries $-j$ for each year t. Its coefficient δ will be our main coefficient of interest throughout. The relative interpretation is identical for our set of country level controls ($X_{j,-j,t}$). Inventor specific characteristics that could likewise influence the emigration decision are captured in the inventor control vector ($X_{i,t}$). We exploit the advantages of the within estimator and employ inventor and time fixed effects. Inventor fixed effects (α_i) control for unobserved time invariant inventor characteristics, such as unobserved ability and preferences, which could bias our estimated coefficients. Time fixed effects (γ_t) capture common trends in out migration across countries that are not accounted for by our covariates. $\epsilon_{i,j,-j,t}$ denotes the error term. The latter is heteroscedastic by construction therefore we use heteroscedasticity robust clustered (at the inventor level) standard errors throughout the empirical analysis. As our dependent variable is at the microeconomic level (inventors) and our independent variable at the macroeconomic level (relative policy uncertainty) a Moulton bias is possible (Moulton, 1990). To account for this we also replicate all our major results with bootstrapped standard errors (Appendix D), although this does not prove to be meaningfully impactful.

4.1 Basic Results

In our first pass we find evidence of a significant relationship between policy uncertainty and inventor emigration. Our coefficient of interest grows from 0.0049, in our most basic specification with only inventor and time fixed effects, to 0.0063 when all inventor and country level control variables are included.

The results are presented in table 2. For the Within Estimator a one unit increase in REPU will result in an increase of 0.0063 units in the ratio of emigrating to non-emigrating inventors in that year. We consider the baseline fraction of emigrating inventors to be 0.00514 (the average in our sample). Meaning a one unit increase in REPU would be more than double the fraction of emigrating inventors. However, a one unit increase in the relative uncertainty measure would be uncommonly large. A more suitable interpretation would be for a one standard deviation rise in relative policy uncertainty. Or a rise of 0.215. For the one standard deviation rise in uncertainty our fraction of emigrating inventors now increases by $0.00135 (= 0.215 * 0.0063)$. The effect relative to our baseline is then a 26.26% $(= (0.00135/0.00514) * 100)$ increase in the inventor emigration rate.

The Logit estimations differ in that only inventors who are observed to migrate are considered. This changes our coefficient interpretation. Here, our estimation with all controls included returns a coefficient of 0.277. This can be interpreted in probability terms after adjusting the Logit link function. The coefficient represents a marginal effect of a 31.92% increase in the inventor emigration probability.

Some of the other predictions of equation 6 are validated. Inventor emigration is decreasing in the income level of the home country. Likewise, all the variables utilised to capture quality of life take their expected signs with the exception of institutional strength.[16] The negative sign on foreign collaborators initially seems surprising. However, it may reflect that inventors with existing networks find it less necessary to relocate for career reasons. It could also reflect that those with more

[16]The relationship between institutions, corruption and emigration in the prior literature is specific to developing countries where corruption can be high and institutions particularly weak. Our sample is composed solely of developed countries with comparatively strong institutions so a non-negative effect is not surprising.

Table 2: Basic Results

	Within Estimator			Conditional Logit		
	(1)	(2)	(3)	(4)	(5)	(6)
Policy Uncertainty	0.0049***	0.0063***	0.0063***	0.2935***	0.3566***	0.2766***
	(0.0000)	(0.0000)	(0.0000)	(0.0005)	(0.0002)	(0.0061)
GDP Per Capita		-0.0038	-0.0043*		-0.2635**	-0.0802
		(0.1210)	(0.0785)		(0.0470)	(0.5737)
Inflation		0.0923***	0.0887***		0.2426	-2.9483**
		(0.0000)	(0.0000)		(0.8340)	(0.0159)
Employment Rate		-0.0435***	-0.0435***		0.0748	1.4509
		(0.0026)	(0.0025)		(0.9547)	(0.3038)
Crime		0.0014	0.0015		-0.3376**	-0.2110
		(0.4549)	(0.4442)		(0.0102)	(0.1314)
Institutional Strength		0.0166***	0.0164***		0.9021***	0.4350
		(0.0000)	(0.0000)		(0.0008)	(0.1305)
Patent Stock			-0.0006***			-0.3853***
			(0.0000)			(0.0000)
Citations			0.0001			0.0118
			(0.4571)			(0.6914)
Foreign Collaborators			-0.0103***			-1.6414***
			(0.0000)			(0.0000)
Inventor Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	1746661	1626963	1626963	43961	39859	39859

All standard errors are robust to heteroscedasticity and clustered at the inventor level. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$). The emigration dummy is the dependent variable in all regressions. The within estimation ((1)-(3)) uses the entire sample of inventors both emigrators and those who remain fixed for the duration of our sample period. The Logit estimations (columns (4)-(6)) considers only inventors who are observed to emigrate at some point in their career.

developed international networks are older and therefore are unconditionally less likely to move. In Appendix B we show the results of interacting relative policy uncertainty with foreign collaborators. We observe that inventors with more foreign collaborators emigrate more under policy uncertainty.

4.2 Identification

Our setup comes with several concerns around identification. Underlying our relative uncertainty measure is the EPU, which registers uncertainty based on the content of news articles. It is feasible that the behaviour of inventors influences the frequency of uncertainty suggesting terms appearing in newspapers. For instance, a period of heightened inventor outflows may receive significant press coverage leading the EPU to a higher policy uncertainty value. Giving us a reverse causality issue. In order to further investigate policy uncertainty's role as a determinant of inventor emigration we regress the first difference of our relative policy uncertainty measure on the leaving dummy (equation 9). Our dependent variable now becomes $\Delta REPU_{i,j,-j,t+1} = REPU_{i,j,-j,t+1} - REPU_{i,j,-j,t}$ or the change in uncertainty between periods t and $t+1$ faced by inventor i who potentially emigrated from country j to country $-j$ in period t. The primary covariate of interest is the emigration dummy ($LEAVE_{i,j,-j,t}$) which takes a value of 1 if the inventor emigrates in the period and 0 otherwise.

$$\Delta REPU_{i,j,-j,t+1} = \delta LEAVE_{i,j,-j,t} + \beta X_{j,-j,t} + \beta X_{i,t} + \gamma_t + \alpha_i + \epsilon_{i,j,-j,t+1} \qquad (9)$$

Table 3: Post Emigration Uncertainty

	(1)	(2)	(3)
Previous period emigration	-0.0260***	-0.0396***	-0.0396***
	(0.0051)	(0.0001)	(0.0001)
Country Controls	No	Yes	Yes
Inventor Controls	No	No	Yes
Inventor Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
N	1284814	1193970	1193970

https://www.overleaf.com/project/618505aefec8d7a37e5cd67b
All standard errors are robust to heteroscedasticity and clustered at the inventor level. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$). The dependent variable in all three columns is the differenced relative uncertainty measure.

Table 3 provides the results. We see that emigrating inventors are subsequently exposed to lower policy uncertainty than their stationary peers. Across all specifications the results are statistically significant. We find that emigrating inventors face a relative policy uncertainty of $1/5th$ of a standard deviation lower after emigrating. While such a check cannot rule out a reverse causality issue,[17] our finding that migrating inventors move to destinations with lower policy uncertainty continues to motivate our interest in policy uncertainty as a determinant of out migration.

The presence of confounding factors is less of a concern as most factors which could have a simultaneous influence on policy uncertainty and emigration decisions are observable [18] and are captured by our country control vector ($X_{j,-j,t}$).

[17]If the policy uncertainty level of the origin country increases upon inventor emigration - while the destination country remains at trend level - the inventors' exposure to policy uncertainty would decrease in the subsequent periods.

[18]Crime rates, institutional quality and business cycle conditions could all have simultaneous influence over the inventor emigration decision and policy uncertainty.

Along with the potential for a reverse causality issue, there is the worrying possibility of measurement error. As noted earlier, underlying our relative uncertainty measure is the EPU index which rises based on terms appearing in the major newspapers of each nation. Different cultural norms by country may influence the degree to which uncertainty suggesting terms appear in major newspapers. Or, in some countries the major papers may have a prior disposition to report more frequently on economic and policy matters in any case. Naturally giving rise to greater use of economic, policy and uncertainty terms in news articles. A situation in which a major newspaper undergoes a gradual change in content over time whereby they organically increase or decrease their reporting of economic and business matters could also have significant influence over the index. Any such noise underlying our relative uncertainty measure could bias our coefficient of interest.

4.3 Two Stage least Squares

Concerned that equation (8) may produce biased estimates we move forward with an instrumental variable strategy. This relies on our ability to identify a source of exogenous variation in our uncertainty measure which is otherwise uncorrelated with the determinants of inventor emigration.

We exploit the timing of close elections as a source of plausibly exogenous variation in policy uncertainty. Elections generate policy uncertainty through the potential for a change in government or a strengthened mandate for the incumbent. This theoretically relies on the decision maker being unable to confidently predict the outcome of the election. For this reason we focus on close elections, under the assumption that elections which ended up being close were more difficult to predict prior to the election. In this we follow existing literature (Atanassov et al., 2015) and define an election as close if the winning margin is below 5%.

We are encouraged by the choice of instrument for several reasons. The channels noted above have received some empirical evidence. In particular, the input to our relative uncertainty measure, the EPU, has itself been shown to rise during election years (Baker et al., 2020). And beyond their association with policy uncertainty there is little reason to believe close election timing has an alternative channel of correlating with inventor emigration. Elections are fixed in time by law so are by nature predetermined with an exogenous point of timing.[19]

We obtain election data from the World Bank's Database of Political Institutions. We do so for the same time frame and set of countries for which we follow inventor emigration and the EPU. The data is then treated to determine whether the primary election is presidential or parliamentary and whether the election had an eventual margin of victory below 5%. If so, we assign a value of 1 to the close election year dummy. Exact details on the construction of our close election variable are given in Appendix E and descriptive statistics on our election data are given in Appendix A.

Our close elections instrument allows us to re-estimate equation 8 through a Two Stage Least Squares estimation. The second stage remains as above (equation 8) but with REPU now being replaced by its fitted value. The first stage regresses the relative policy uncertainty measure on our close election timing instruments. It is shown below (equation 10).

$$REPU_{j,-j,t} = \delta CloseElec_{j,t} + \delta CloseElec_{j,t-1} + \beta X_{i,t} + \beta X_{j,-j,t} + \alpha_i + \gamma_t + \epsilon_{j,-j,t} \quad (10)$$

The inventor and country control vectors are included, as before. As are inventor level and time fixed effects. We use a close election timing dummy ($CloseElec_{j,t}$) and it's lag ($CloseElec_{j,t-1}$) as instruments. The former being included per the reasoning above. The inclusion of the latter allows us to account for uncertainty

[19] This is true for all the elections in our sample with the exception of Germany in 2005 and Greece in 2012.

in the aftermath of close election results. It should be noted that unlike our first stage dependent variable, the close election dummies are not relative. We argue that higher relative uncertainty would be expected in country j relative to the set of destination countries ($-j \neq j$) provided that the set of possible destination countries do not all have elections in the same year. Our election dummy has significant cross sectional variation so this does not prove to be an issue.

4.4 Two Stage Least Squares - Results

We illustrate the results of our Two-stage least squares estimations in the tables below. Table 4 shows the second stage results and Table 5 the first stage. In our preferred specification, with controls at the inventor and country level (table 4, column 2), our coefficient has has increased from 0.0063 in the first pass to 0.0095. For a one standard deviation increase in relative uncertainty in the inventors home country this would equate to the fraction of emigrating inventors increasing by 0.00204.[20] Adjusting for the low average fraction of emigrating inventors in our sample (0.00514), the coefficient represents a 39.69% [21] increase in the inventor emigration rate relative to the baseline.

The implication of the increased coefficient size in our 2SLS specifications seems to validate our earlier discussion on some bias afflicting our estimates. A reverse causality issue in which the relative uncertainty measure responds to inventor emigration would have overestimated our earlier results (table 2). Given the significant rise in our coefficient, the unlikely nature of inventor emigration receiving such no-

[20] 0.0095 adjusted for the standard deviation of REPU. 0.215*0.0095 = 0.00204.

[21] (0.00204/0.00514)*100 = 39.69%

Table 4: Two-Stage Least Squares Results

	(1)	(2)
Policy Uncertainty	0.0090**	0.0095**
	(0.0152)	(0.0107)
GDP Per Capita	0.0042	0.0042
	(0.1108)	(0.1140)
Inflation	0.1064***	0.1062***
	(0.0000)	(0.0000)
Institutional Strength	0.0122***	0.0125***
	(0.0001)	(0.0000)
Employment Rate	-0.0538***	-0.0539***
	(0.0016)	(0.0016)
Crime	-0.0037	-0.0034
	(0.1098)	(0.1422)
Patent Stock		-0.0006***
		(0.0000)
Citations		0.0000
		(0.6451)
Foreign Collaborators		-0.0058***
		(0.0000)
First Stage Results:		
Close Election	0.0326***	0.0326***
	(0.0000)	(0.0000)
Close Election lag	0.0799***	0.0799***
	(0.0000)	(0.0000)
Inventor Controls	No	Yes
Country Controls	Yes	Yes
N	1222012	1222012
Inventor Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
F Statistic	6516	6517
R^2	0.34	0.34

The lower panel shows the results of the first stage regression of a close election year dummy and it's lag on the relative uncertainty measure. The F statistic is reported on the excluded instruments of the two close election dummies. The upper panel presents the second stage results. The inventor specific emigration dummy is the dependent variable. Across both stages standard errors are robust to heteroscedasticity and clustered at the inventor level. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$).

table press coverage [22] and our earlier finding that emigrating inventors face notably lower uncertainty in the years after moving, this seems unlikely as the source of bias. A moderate form of measurement error seems intuitively more plausible and would be consistent with the downward bias we observe.

The lower panel (table 5) shows the main results of the first stage. Across all specifications both instruments are positive as expected and statistically significant. The F statistic is extremely large across all specifications. We test the validity of the instruments through Hansen's J test, which is not rejected ($\chi^2 = 1.71$, p-value $= 0.19$).

4.5 Robustness

We now culminate our analysis with several robustness checks in this section and a back of envelope calculation in the next. Table 6 shows how the results of our basic and 2SLS-FE estimations change when Germany is omitted from the sample, when a terror based index is included and a when an alternative income specification is used.

In the first two columns we re-estimate our models with the largest source of inventors, Germany, excluded from the sample. This allows us to check that the results are not being driven by the largest country in our dataset. Such a concern is clearly rejected with the coefficient in both estimations growing further. The 2SLS coefficient in particular now more than doubles in size and becomes significant beyond the 99th percentile.

An increase of this magnitude is not unexpected. Elections in Germany typically involve a race between two or more parties with relatively similar policy positions compared with other countries (Baker et al., 2020). By our earlier argument this would reduce the strength of the relationship between our first stage instruments and

[22] The inventor emigration rate is typically low for the developed countries in our data set and unlikely to be the subject of the consistent coverage needed to create a major bias

our relative policy uncertainty variable biasing the estimates towards those in the first pass (table 2). Furthermore, inventors from Germany are less likely to emigrate during our sample period in any case. When Germany is omitted the average annual inventor emigration rate of the remaining sample rises by more than 30%. However, the fact our basic estimation (column 1) remains close to unchanged suggests that the increase in the strength of the first stage instruments is responsible for the large jump.

In columns (3) and (4) we test whether our results are robust to the inclusion of a terror based index.[23] Earlier we noted that the underlying uncertainty measure spikes in response to events such as terrorist attacks.[24] This brings a concern that our coefficient may (partially) capture the broader impact of these events rather than just uncertainty. The results are shown in columns (3)-(4). The coefficients on our relative uncertainty measure are unchanged for both the within and IV-2SLS estimations. We fail to find any evidence that the observed increases in inventor emigration is associated with safety concerns rather than policy uncertainty.

Finally we show our results are robust to the inclusion of alternative income proxy variable. As discussed earlier we lack an inventor level income metric or our preferred country level proxy, occupational wage shares for science, engineering and higher education professions, instead using GDP per capita as an income proxy. This comes with the concern that GDP per capita may not accurately reflect the incomes of inventors. In particular, countries with higher GDP per capita may not necessarily have higher incomes in inventive professions. With inventors frequently earning incomes in the upper quantiles of the income distribution (Bell et al., 2019). Countries which offer high salaries in inventive professions but have lower per capita

[23]We use the Global Terrorism Index from the Institute for Economics and Peace.

[24]In the month following the London bombings the UK policy uncertainty index jumped by more than 30 points. The US index increased by more than 175 points in the aftermath of the 9/11 terror attacks.

income would violate the assumption behind our income proxy. To reflect this possibility we re-estimate our models with the 90th percentile of a countries' income distribution as our income proxy.[25] The coefficients (columns (5)-(6)) are largely unchanged and the top quantile income proxy fails to achieve statistical significance.

4.6 Implications

The majority of changes in behaviour observed under uncertainty are reversible and can rebound significantly when uncertainty subsides (Bloom, 2009). Emigration is much more difficult to reverse and much of the inventor emigration we observe is likely to be permanent. Emigration under uncertainty thus has long term policy implications which deserve further exploration. With this in mind it is natural to investigate the extent to which our findings pertain to innovation at the aggregate level. We move to offer insight with a back of the envelope calculation. We consider a country specific uncertainty shock which raises the relative policy uncertainty of the country by one standard deviation for a period of one year. We make a rough estimation of the inventions made by departing inventors in the 10 years following their departure to offer an idea of the cost a short period of uncertainty can create through lost human capital.

Prior estimates of migration and invention have repeatedly found heightened inflows of skilled to be associated with stronger innovation outcomes (Peri (2012); Hunt and Gauthier-Loiselle (2010); Stuen et al. (2012); Kerr and Lincoln (2010)). More pertinently, the reverse appears to also hold true. Agrawal et al. (2011) find inventor emigration to be harmful to the domestic economy in India. However, there is minimal research on brain drain from developed economies.

[25] Like earlier this is taken to be a relative measure with host country income divided by the average income of the set of the possible income distributions.

Table 5: Robustness Tests

	No Germany		With Terror Index		With High Income Control	
	(1)	(2)	(3)	(4)	(5)	(6)
Policy Uncertainty	0.0069***	0.0206***	0.0064***	0.0095***	0.0068***	0.0086**
	(0.0000)	(0.0000)	(0.0000)	(0.0056)	(0.0000)	(0.0319)
Safety			-0.0008	0.0013**		
			(0.1912)	(0.0487)		
Top Income Quantile					0.0033	0.0030
					(0.1829)	(0.5154)
Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Inventor Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Inventor Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	731646	511439	1626963	1222012	1626963	1222012

The first two columns report coefficients from the within and two-stage least squares estimations, respectively. Germany is omitted from our sample. The third and fourth columns again show the results of within and 2SLS estimations. In this instance with the terror index included as an additional country level control. The 5th and 6th columns replace (relative) GDP Per Capita with the (relative) 90th percentile of the income distribution. Data on income quantiles are obtained from Eurostat. Missing values are imputed based on historical trends. All standard errors are robust to heteroscedasticity and clustered at the inventor level. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$).

We obtain information on patents granted in each country in our sample for 2011. In the interest of this experiment we consider only patents granted to residents of the given country. We create an innovation portfolio of a representative country through a simple average of the number of active inventors in the country and the number of patents granted to the residents in the affected year. Through the increase in relative policy uncertainty the country experiences a 39.69% (our IV estimate) increase in the inventor emigration rate that year.

In 2011 the total patents granted to residents was 54,781 across our sample countries,[26] giving our average country 6848 patents granted to the 8885 inventors who were residents in 2011. The heightened period of policy uncertainty raises the emigration rate (set at 0.746%, our 2011 average) by 39.69% (adjusting our final 2SLS coefficient to reflect a rise of one standard deviation) to 1.05%.

For this simplified experiment we assume the departing inventors are representative of their peers, and the superstar inventors responsible for the majority of patents (and particularly citations) are as likely to depart as their peers. When exploring our results (Appendix B) we added a interaction of relative policy uncertainty with our ability proxy, citations per patent, and found no evidence of a heterogeneous response based on ability. Giving us reason to feel this assumption is fair for this exercise.

Each inventor produced $0.771(= 6848/8885)$ patents in 2011. The baseline emigration rate suggests 66 inventors would depart in any case. This increases to 93 under the heightened relative uncertainty.

As noted above, unlike most commonly studied decisions, emigration is unlikely to be reversed after the uncertainty subsides. The $21(= 27 * 0.771)$ additional patents lost in the departure year may seem trivial relative to the 6848 patents granted in this hypothetical country-year pairing. However, assuming a constant productivity

[26]With the omission of Greece and Ireland who are excluded due to data availability.

for the inventors, 210 extra patents are lost in the subsequent decade. Adjusting this for the average patent value of 10.36 million dollars calculated by Kogan et al. (2017),[27] the value of additional lost patents from the temporary increase in relative policy uncertainty would exceed 2 billion dollars over the next decade.

Of course, these estimates are vaguely calculated and should be interpreted with caution. They seek to illustrate how this newfound relationship between policy uncertainty and inventor emigration can have notable effects at the aggregate level. It is possible that a notable increase in policy uncertainty could increase innovation should a rise in uncertainty increase inward inventor immigration. Although, this would be the opposite of what our theory predicts, and given for the purpose of this calculation we assume that the emigrating inventors are of equal productivity to non-emigrating inventors (which restricts the number of patents per inventors given the large number of non-emigrating inventors who only patent once in our sample[28]) and that there are no local knowledge spillovers to be gained through having active inventors in the country, our results feasibly constitute a significant underestimate of any aggregate effect.

4.7 External Validity

Beyond inventors in Europe there is reason to believe our results are not only inferable to similar settings but are also conservative estimates of the impact of policy uncertainty on high skilled emigration.

Inventors in Europe experience particularly low unconditional emigration rates. Given this trend in our European sample, our results may have larger aggregate implications in other developed nations, such as the United States, where unconditional emigrations rates are higher.

[27]This average patent value is arguably large. However, we opt for the average patent value rather than median given the assumption that superstar inventors are at least as equally likely to emigrate as their less productive peers.

[28]Emigrating inventors by definition must patent at least twice.

Additionally, there is no reason to believe inventor specific characteristics explain their heightened emigration rates under policy uncertainty. Indeed, in our earlier empirical analysis, our relative policy uncertainty coefficients remain almost unchanged when inventor level information is conditioned on (the shift from column (2)-(3) in table 2 and from (1)-(2) in table 4). Other groups similar to inventors, such as high-skilled labour more generally, could feasibly experience similar increases in emigration under policy uncertainty.

Our setting is however unsuitable for inference to low skilled labour or those with origins in developing countries. Low skilled labour are unlikely to face the same opportunities to emigrate unconditionally, so any attempts to emigrate under policy uncertainty could be constrained by the lack of available opportunities abroad. Migrants from developing countries could be motivated more by income, which will have a higher potential difference between origin and destination country than those originating in developed countries, and face the issue that policy uncertainty is hard to disentangle from threat of political revolutions or large natural events which can have a significant impact on emigration for reasons aside from policy uncertainty.

5 Conclusion

This paper considers policy uncertainty as a novel determinant of emigration. We develop a simple stylised representation of the inventor emigration decision which introduces relative policy uncertainty as a factor which lowers the utility of emigration when relatively higher in the destination country and raises the utility of emigration when relatively higher in the home country.

All inventors face a baseline level of uncertainty surrounding the migration process, capturing their inability to perfectly forecast future payoffs at the time of the emigration decision. A higher relative policy uncertainty abroad exacerbates the difficulty of forecasting future outcomes. A higher relative policy uncertainty at home introduces the same difficulty of forecasting future conditions to the home country, mitigating the role of uncertainty in the emigration decision.

In our empirical setting of European inventors we find evidence of increased mobility under policy uncertainty. In our first pass we use the within estimator, with an array of time varying controls added across specifications, and find that a one standard deviation increase in the relative policy uncertainty of the home country increases the fraction of emigrating inventors by over 26%. When accounting for a potential endogeniety bias our two-stage least squares estimates grow further to a near 40% increase in the rate of emigrating inventors for the same one standard deviation rise in relative uncertainty.

In further exploring our mechanism we find that inventors who do emigrate are exposed to significantly lower levels of policy uncertainty in the years following the move. Further emphasising the role of policy uncertainty in the emigration decision.

While our results are highly significant, they occur on a fairly uncommon phenomena, inventor emigration. We address any concern that our results are trivial at the aggregate level with a back of the envelope calculation. We show that a nation which faces an elevated relative policy uncertainty level for one year would lose over 2 billion dollars in innovative output in the ensuing decade through additional inventor out migration.

There is no reason to suggest some inventor specific characteristic is responsible for their increased rate of emigration under policy uncertainty. Other high skilled populations in particular will have similar opportunities to emigrate making our results credibly inferable to all high-skilled labour.

Overall, our results provide maiden evidence that policy uncertainty is a determinant of emigration through our setting of European inventors. Our findings suggest that the connection between policy uncertainty and emigration should receive more attention from scholars and policymakers alike.

Appendix A Election Descriptives

Table 6: Election Descriptives

Country	Primary Election	Number of Elections	Number of close elections
Belgium	Parliamentary	6	2
Croatia	Presidential	5	0
France	Presidential	4	1
Germany	Parliamentary	6	3
Greece	Parliamentary	7	5
Ireland	Parliamentary	5	0
Italy	Parliamentary	6	2
Spain	Parliamentary	6	2
Sweden	Parliamentary	6	1
United Kingdom	Parliamentary	5	1

This table shows the number of elections and number of close elections (winning margin $< 5\%$) for each country in our sample.

Appendix B Inventor heterogeneity

Table 7: Inventor Heterogeneity

	(1)	(2)	(3)
Policy Uncertainty	0.0060***	0.0063***	0.0066***
	(0.0000)	(0.0000)	(0.0000)
Patent Stock	-0.0006***	-0.0005***	-0.0004***
	(0.0000)	(0.0000)	(0.0000)
Citations	0.0001	-0.0000	0.0001
	(0.4624)	(0.7071)	(0.4601)
Foreign Collaborators	-0.0151***	-0.0103***	-0.0103***
	(0.0000)	(0.0000)	(0.0000)
Policy Uncertainty X Foreign Collaborators	0.0044***		
	(0.0047)		
Policy Uncertainty X Citations		-0.0001	
		(0.9666)	
Policy Uncertainty X Patent Stock			-0.0001
			(0.2168)
Inventor Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes
N	1626963	1626963	1626963

All standard errors are robust to heteroscedasticity and clustered at the inventor level. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$). The three columns show our primary covariate, relative policy uncertainty, along with each of the inventor level covariates. The bottom three rows show the results of the interaction of each inventor level covariate with relative policy uncertainty. In the case of the Citations-Uncertainty interaction, the top quantile of the citations per patent distribution is used rather than citations per patent.

Appendix C Alternative Move Assumption

Table 8: Basic Results

	(1)	(2)	(3)
Policy Uncertainty	0.0033***	0.0050***	0.0050***
	(0.0000)	(0.0000)	(0.0000)
Country Controls	No	Yes	Yes
Inventor Controls	No	No	Yes
Time Fixed Effects	Yes	Yes	Yes
Inventor Fixed Effects	Yes	Yes	Yes
N	1929998	1695522	1695522

The upper and lower panel show our main results with an alternative assumption on the timing of inventor emigration. The upper panel replicates our basic results. The lower panel replicates the second stage of our 2SLS estimation. All standard errors are robust to heteroscedasticity and clustered at the inventor level. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors ($^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$).

Table 9: 2SLS Results

	(1)	(2)
Policy Uncertainty	0.0099***	0.0101***
	(0.0031)	(0.0026)
Country Controls	Yes	Yes
Inventor Controls	No	Yes
Time Fixed Effects	Yes	Yes
Inventor Fixed Effects	Yes	Yes
N	1262694	1262694

Appendix D Bootstrapped Standard Errors

Table 10: Basic Results

	Fixed Effects			Logit		
	(1)	(2)	(3)	(4)	(5)	(6)
Policy Uncertainty	0.0049***	0.0063***	0.0063***	0.2935***	0.3566***	0.2766**
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0281)
GDP Per Capita		-0.0038	-0.0043		-0.2635	-0.0802
		(0.1313)	(0.1294)		(0.1257)	(0.7111)
Inflation		0.0923***	0.0887***		0.2426	-2.9483
		(0.0000)	(0.0000)		(0.8823)	(0.1139)
Employment Rate		-0.0435***	-0.0435***		0.0748	1.4509
		(0.0033)	(0.0029)		(0.9604)	(0.4341)
Crime		0.0014	0.0015		-0.3376*	-0.2110
		(0.3998)	(0.3943)		(0.0507)	(0.2368)
Institutional Strength		0.0166***	0.0164***		0.9021***	0.4350
		(0.0000)	(0.0000)		(0.0054)	(0.1835)
Patent Stock			-0.0006***			-0.3853***
			(0.0000)			(0.0000)
Citations			0.0001			0.0118
			(0.4709)			(0.7730)
Foreign Collaborators			-0.0103***			-1.6414***
			(0.0000)			(0.0000)
Inventor Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	1746661	1626963	1626963	43961	39859	39859

The panel replicates our first pass regression shown in table 2 of the main paper. Standard errors are bootstrapped. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$).

Table 11: Previous Period Emigration

	(1)	(2)	(3)
Previous period emigration	-0.0260**	-0.0396***	-0.0396***
	(0.0163)	(0.0000)	(0.0000)
Country Controls	No	Yes	Yes
Inventor Controls	No	No	Yes
Inventor Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
N	1284814	1193970	1193970

The panel replicates our test on the change in uncertainty experienced by emigrating inventors compared to their non-emigrating peers (main results shown in table 3 of the main paper). Standard errors are bootstrapped. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors ($^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$).

Table 12: Two-Stage Least Squares Results

	(1)	(2)
Policy Uncertainty	0.0090**	0.0095***
	(0.0163)	(0.0065)
GDP Per Capita	0.0042*	0.0042*
	(0.0853)	(0.0745)
Inflation	0.1064***	0.1062***
	(0.0000)	(0.0000)
Institutional Strength	0.0122***	0.0125***
	(0.0000)	(0.0000)
Employment Rate	-0.0538***	-0.0539***
	(0.0002)	(0.0002)
Crime	-0.0037*	-0.0034*
	(0.0840)	(0.0794)
Patent Stock		-0.0006***
		(0.0000)
Citations		0.0000
		(0.6634)
Foreign Collaborators		-0.0058***
		(0.0000)
Inventor Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
N	1222012	1222012

The lower panel shows the results of the first stage regression of a close election year dummy and it's lag on the relative uncertainty measure. The F statistic is reported on the excluded instruments of the two close election dummies. The upper panel presents the second stage results. The inventor specific emigration dummy is the dependent variable. Across both stages standard errors are bootstrapped. Given the low unconditional emigration rate in our sample, the coefficients, and particularly the standard errors, are small and require numerous decimal places. In order to be parsimonious we opt to report p values in brackets rather than the traditional standard errors (*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$).

Table 13: First Stage Results

	(1)	(2)
Close Election	0.0326***	0.0326***
	(0.0000)	(0.0000)
Close Election lag	0.0799***	0.0799***
	(0.0000)	(0.0000)
Country Controls	Yes	Yes
Inventor Controls	No	Yes
Inventor Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
F Statistic	6516	6517
R^2	0.34	0.34
N	1222012	1222012

Appendix E Close Election Instrument Construction

First, we generate a dummy for all election years using the World Bank's Database for Political Institutions as an input. The key columns of interest are the dummies for legislative elections (henceforth legelec) and executive elections (henceforth exelec).

As a first step the election dummy is provisionally generated by matching the system – listed in the original dataset – to its most appropriate election dummy i.e. presidential systems have an election year only when exelec is active and parliamentary systems only when legelec is active. Two major issues still remain.

The system listed in the World Bank's database is often a misleading indicator of how political power is distributed in a given nation. For example, in a number of nations, the role of president is largely ceremonial and the political power lies with the prime minister, yet this is still classified as a presidential system. Likewise, many countries have a semi presidential framework where duties are dispersed between multiple leaders. This issue is solved by manually checking the political structure of each country to verify the most important election type is identified. In other words, to ensure that whichever election, legelec or exelec, holds greater importance in the future policy of the given country is assigned as the election dummy. In the cases, notably semi-presidential republics, where this was still inconclusive, the election dummy is set to the electoral framework which, on average, receives the highest voter turnout.

An important final distinction would be countries which change structure or have a sudden shift- in election credibility during the jurisdiction of the Global Elections Dataset. These are not dropped provided they have at least one major leadership election - which has an uncertain outcome, between 1990 and 2012 - and the global elections dataset will account for the change in structure by switching between legelec and exelec, or by censoring non-credible election years. However for our sample of interest, this isn't an issue.

With this we have identified the primary election of our countries of interest. The close election dummy is then set to one when two conditions are satisfied. The difference between the two highest vote shares (typically gov1vote and opp1vote) is less then 5 and there was a primary election in the period.

Appendix F Data Sources

The EPU index for France, Germany, Italy, Spain and United Kingdom is all obtained from https://www.policyuncertainty.com/ and Baker, S.R., Bloom, N. and Davis, S.J., 2016. Measuring economic policy uncertainty. The quarterly journal of economics, 131(4), pp.1593-1636.

The remaining countries are retrieved from the following sources:

Belgium EPU: Algaba, A., Borms, S., Boudt, K. and Van Pelt, J., 2020. The economic policy uncertainty index for Flanders, Wallonia and Belgium. BFW digitaal/RBF numérique, 6.

Croatia EPU: Sorić, P. and Lolić, I., 2017. Economic uncertainty and its impact on the Croatian economy. Public Sector Economics, 41(4), pp.443-477.

Greece EPU: Fountas, S., Karatasi, P. and Tzika, P., 2018. Economic policy uncertainty in Greece: measuring uncertainty for the greek macroeconomy. South-Eastern Europe Journal of Economics, 16(1).

Ireland EPU: Zalla, R., 2017. Economic policy uncertainty in Ireland. Atlantic Economic Journal, 45(2), pp.269-271.

Sweden EPU: Armelius, H., Hull, I. and Köhler, H.S., 2017. The timing of uncertainty shocks in a small open economy. Economics Letters, 155, pp.31-34.

Terror Index: Global Terrorism Index (2022 version) https://www.visionofhumanity.org/public-release-data/

Patents Granted to Residents: WIPO IP Statistics Data Center https://www3.wipo.int/ipstats/index.htm?tab=patent

Consumer Price Index: World Bank https://data.worldbank.org/

GDP Per Capita: World Bank https://data.worldbank.org/

Homicides: Eurostat https://ec.europa.eu/eurostat/web/crime/data/database

Institutional Strength: Corruption Index https://www.transparency.org/en/cpi/2012

Employment rate: World Bank https://data.worldbank.org/

Income Quantiles: Eurostat https://ec.europa.eu/eurostat/web/main/data/database

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