Hiring uncertainty: a new labour market indicator

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Abstract This paper develops a forward-looking indicator for macroeconomic uncertainty that employers are confronted with when they take decisions about the size of their workforce. The model that provides the basis for this uncertainty indicator interprets hires and lay-offs of workers as an investment into projects with uncertain return. Employers decide when to undertake this investment. Uncertainty can then be derived as a function of a labour productivity threshold above which it is profitable for employers to hire workers. The measure that is first theoretically derived is then taken to the data. Economy-wide uncertainty for G7 economies and uncertainty by economic sector for the United States are calculated from data on hiring demand and unit labour costs. The resulting quarterly time series demonstrate that in most economies hiring uncertainty went up at the onset of the Great Recession and has remained at an elevated level since then.

Keywords: Crisis, Employer, Hiring, Risk, Uncertainty, Unemployment

JEL classification: D80, E66, J23, J63

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1 Introduction

Five years after the onset of the Great Recession, many labour markets worldwide are stagnant and high unemployment continues to persist. Particularly in advanced economies, hiring activity of the private sector is still down compared to pre-crisis levels. In the United States, for example, the number of hires in the private sector as percentage of total employment has decreased significantly during the crisis. The hiring rate stood at above 4.0 per cent in every month between April 2003 and February 2008, but has consistently been below 4.0 per cent ever since then. According to the latest data from the US Bureau of Labor Statistics, the hiring rate stood at 3.7 per cent in October 2013, which is still below the hiring rates observed before the crisis. Morissette et al. (2013) find similar evidence on hiring rates for Canada. Also estimates on unemployment outflow rates from the International Labour Office ILO (2013b) point to less hiring activity than before the crisis in many economies.

Hiring can be seen as a real investment option. When hiring new staff, firms invest into an increase of their workforce. They incur a sunk cost which includes the costs of recruitment, training and committed salary payments. In return, they expect that the newly hired workers contribute to larger profits through their productivity. However, apriori it is uncertain how productive new staff can be, given that the macroeconomic environment in which workers operate is uncertain. Even if a firm is perfectly able to assess the skill level of new entrants through appropriate screening measures in the recruitment process, there is some uncertainty about the return to the investment. There are external factors beyond the control of an individual firm, in particular economic policy, that can have an impact on the demand for the firms’ products and services as well as on the conditions of production. These factors, thus, have a bearing on the return that is generated by new staff.

There are two potential explanations for meager hiring rates. Either the expected returns from hiring are too low, so that firms do not expect to generate additional profits by hiring new staff. In other words, there are no profitable investment projects available to firms. Or the uncertainty about

\[^{1}\text{As the ILO (2013a) reports in its Global Employment Trends 2013 report, the global number of unemployed is still by 28 million higher than it was before the crisis. For advanced economies this gap amounts to 14 million.}\]
future returns is too high. So even if there are investment projects available that yield an expected positive return, it is not certain whether such a return will eventually materialize. As a consequence, firms may find it optimal to postpone their hiring decision and wait for new information to come in rather than hiring new workers right away. Several international organizations diagnosed that uncertainty is likely one of the key factors behind the jobless recovery from the economic crisis that has been observed in many countries. As the ILO (2013a) argues in its *Global Employment Trends 2013* report, the lack of policy coordination and the *indecision of policy makers in several countries has led to uncertainty about future conditions and reinforced corporate tendencies to increase cash holdings or pay dividends rather than expand capacity and hire new workers.* In a similar vein, the International Monetary Fund stated in 2012 that there *is a level of uncertainty which is hampering decision makers from investing and from creating jobs.*

Uncertainty cannot be directly observed, but needs to be indirectly inferred from decisions that are influenced by uncertainty. Moreover, there are different types and perceptions of uncertainty. Even though, measuring uncertainty is hence not straight-forward, the literature has come up with some methodologies. Baker *et al.* (2013) developed an economic policy uncertainty index for some of the largest economies. One component of the index measures the coverage of uncertainty in newspapers and counts articles that contain certain word combinations relating to economic policy uncertainty. Another component calculates a measure of forecasters’ disagreement about future prospects of the economy. Bloom *et al.* (2012) use micro-level data on manufacturing plants and take the cross-sectional dispersion of productivity shocks as measure for uncertainty. Baum *et al.* (2006) estimate conditional variances of industrial production, output, inflation and stock price returns with GARCH models and interpret them as indicators for macroeconomic uncertainty. Haddow *et al.* (2013) combine several indicators of uncertainty such as option-implied volatility of equity prices and the above-mentioned economic policy uncertainty index into a summary uncertainty index through principal component analysis.

This paper contributes to this fast-growing literature by proposing a new indicator for macroe-

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economic uncertainty, measuring the uncertainty that employers face when taking hiring decisions. For firms as employers, it is particularly uncertainty about future demand and the conditions of production that can have an impact on their hiring decision. This type of uncertainty, which this paper refers to as hiring uncertainty, can either arise from sources which can be considered as beyond direct control of policy makers, such as terrorism or natural desasters. But it can also arise from uncertainty about economic and financial policies which can directly be influenced by policy makers through their economic policy decisions or absence thereof.

While existing measures from the literature typically assess uncertainty at an economy-wide level, the hiring uncertainty measure that this paper proposes can be derived by economic sector. The level of uncertainty perceived by employers is very likely to depend on the economic sector in which these employers are located. The model that underlies the proposed uncertainty measure has its origin in McDonald and Siegel (1986) who consider the investment decision of a firm. This paper adapts the model to the context of firms’ hiring and lay-off decisions. Firms can decide about the time when to hire workers or, alternatively, when to lay workers off. They only hire workers when the expected return to hiring is strictly larger than the sunk costs incurred. The size of the minimum wedge between return and sunk costs that makes it optimal for firms to invest into their workforce depends on the degree of uncertainty in the economy. Similarly, firms decide to lay workers off when their productivity is lower than the costs. In order to derive an empirical measure on the basis of the theoretical model, this paper introduces the simultaneous investment decision of all firms in an economy and assumes heterogeneity in productivity across firms. The level of uncertainty is then calculated in such a way that it is consistent with the hiring and lay-off plans announced by employers in the economy.

This paper is organized as follows. The next section sets up the theoretical framework on which the hiring uncertainty indicator introduced in this paper is based on. In order to derive an equation for uncertainty that can be applied to actual data, section 3 adds firm heterogeneity to this framework and analyzes the combined decisions of all firms in an economy. Section 4 describes the data that

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4See Dixit and Pindyck (1994) for a textbook presentation of the paper.
are used to derive economy-wide hiring uncertainty for G7 economies and hiring uncertainty in manufacturing and construction for the United States. Section 5 presents and discusses the results. Section 7 concludes by discussing possible extensions and future work.

2 Theoretical framework

As basis for the hiring uncertainty indicator derived in this paper, this section adapts the model set up by McDonald and Siegel (1986) to firms’ hiring and lay-off decisions and analyzes when it is optimal for an individual firm to change the size of its workforce.

2.1 Hiring decision

Consider a firm $i$ that has the option to hire $\bar{a}_i$ workers which is the exogeneously given number of workers required to implement a particular project.\(^5\) Hiring these workers comes along with a sunk cost $\bar{a}_i W_i$ with firm-specific labour cost per worker $W_i$. This sunk cost broadly corresponds to the wage commitment that is irreversibly fixed in the work contracts the firm signs with new staff.\(^6\) The firm expects a return to its investment in the form of the expected value added $\bar{a}_i P_{it}$ that is generated by newly hired staff and sold on the market, where $P_{it}$ denotes firm-specific value added per worker. For example, assume that there is an advanced notice period of three months for laying off workers. The wage commitment then corresponds to three months of wage and salary payments for the newly hired workers. The expected value added is the output that the workers are expected to produce within these three months.

The expected rate of return on the investment can then be written as $V_{it} = \frac{P_{it}}{W_i}$, where $V_{it}$ denotes the expected value added generated by the newly hired workers per unit of sunk cost. $V_{it}$ will

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\(^5\)For example, if the firm hires workers in order to introduce a new product into the market, the firm will hire the amount of workers that is necessary to produce the optimal quantity that the firm wants to sell on the market.

\(^6\)The objective here is to develop an uncertainty measure that can be taken to the data for many countries. As a consequence, recruitment and training costs for which not much data are available are assumed to be small.
also be referred to as labour productivity of firm $i$ in quarter $t$.\footnote{This definition of labour productivity is, for example, also found in Altomonte et al. (2012).} $V_{it}$ is independent of project size $a_i$, given that labour costs and productivity are assumed to be the same for all workers hired by the firm. It is subject to economy-wide productivity shocks and evolves according to a stochastic process that is described by a geometric Brownian motion as follows:

$$dV_{it} = \eta V_{it} dy_t$$

where $dV_{it}$ is the change in labour productivity of firm $i$ over the instant from $t$ to $t + dt$.\footnote{Only economy-wide productivity shocks are considered, so $dy_t$ is the same for all firms $i$.} Future changes in labour productivity are subject to economy-wide productivity shocks that are embedded into the expression $dy_t$ which is a Wiener process, that is, it can be written as

$$dy_t = \epsilon_t \sqrt{dt}$$

with $\epsilon_t$ as a standard normally distributed random variable with zero mean and a standard deviation of one. Moreover, the random variable $\epsilon_t$ is serially uncorrelated so that $E[\epsilon_t \epsilon_s] = 0$ for any $t \neq s$.

The current value of labour productivity is known, so when the firm decides to hire, it knows with certainty which payoff its decision will yield. In contrast, future labour productivity is uncertain, so the firm does not know how these payoffs will evolve in the future. Equations (1) and (2) imply that the future level of labour productivity is distributed log-normally. The variance grows linearly with the time horizon, so there is less uncertainty about labour productivity tomorrow compared to one year from now. $\eta$ provides a measure for the standard deviation of the economy wide shocks. $\eta$ will be referred to as hiring uncertainty.

The possibility to hire a worker can be interpreted as an option for the firm to invest in a real asset. If the firm has the possibility to hire $a_i$ workers, it possesses $a_i W_i$ units of this option. The firm optimally chooses time $t$ at which it undertakes the investment and hires workers, assuming that the time horizon is infinite, so that the solution does not depend on time. The chosen point of time
should maximize the expected net present value of an option which can be written as

\[ F(V_{it}) = E[V_{it} - 1] e^{-\rho t} \]  \hspace{1cm} (3)

where \( E[...] \) is the expected value of the project, given information up to time \( t \). \( \rho \) is the time discount factor, which is assumed to be valid economy-wide. The maximization is subject to the stochastic process for labour productivity that is defined in equation (1).

It can be shown that the solution to this problem consists of a single threshold for productivity \( V_i^{h*} \). Only if productivity exceeds this value the firm will invest and hire workers. If productivity is below this threshold, the firm will find it optimal to wait rather than invest into the project. Since the time horizon is assumed to be infinite, the threshold will not be dependent on time.

To find this threshold, we set up the Bellman equation which describes the value of the option as the maximum of two possibilities. If the firm invests immediately, it gets \( V_{it} - 1 \). If it instead waits \( dt \) with the investment, it gets the expected continuation value \( E[F(V_{i,t+dt})] \), discounted with discount factor \( \rho dt \). The Bellman equation can be written as

\[ F(V_{it}) = \max \left\{ V_{it} - 1, \ E \left[ \frac{1}{1 + \rho dt} F(V_{i,t+dt}) \right] \right\} . \]  \hspace{1cm} (4)

If \( V < V_i^{h*} \), so that productivity is below the threshold that still needs to be established, then the second argument of the maximum function exceeds the first one. In other words, the continuation value is larger than the payoff from investing immediately. As a consequence, the following expression holds

\[ F(V_{it}) = E \left[ \frac{1}{1 + \rho dt} F(V_{i,t+dt}) \right] . \]  \hspace{1cm} (5)

which can be transformed by multiplying with \((1 + \rho dt)\) and subtracting \( F(V_{it}) \) on each side to

\[ \rho F(V_{it}) dt = E[dF_{it}] \]  \hspace{1cm} (6)

See Dixit and Pindyck (1994) for technical details.
with \( dF_{it} = F(V_{it+dt}) - F(V_{it}) \). Next, we apply Ito’s Lemma and expand \( dF_{it} \) as follows:

\[
E[dF_{it}] = \frac{1}{2} \eta^2 V_{it}^2 F''(V_{it}) dt.
\] (7)

Plugging (7) into (6) and dividing by \( dt \), we obtain the following expression:

\[
\frac{1}{2} \eta^2 V_{it}^2 F''(V_{it}) - \rho F_{it} = 0.
\] (8)

This equation needs to be satisfied within the continuation region, when \( V_{it} < V_{i}^{h*} \). But it also needs to be satisfied at the boundary of the continuation region, when the firm is indifferent between hiring workers and waiting, so it needs to hold for \( V_{it} = V_{i}^{h*} \).

If \( V_{it} > V_{i}^{h*} \), then the firm will invest and hire workers. In this case, the first argument of the maximum function in (4) exceeds the second one, so that the payoff from immediately investing is larger than the continuation value. This implies that

\[
F(V_{it}) = V_{it} - 1.
\] (9)

This equation holds when \( V_{it} > V_{i}^{h*} \), but it also holds at the boundary, when the firm is indifferent between hiring workers and waiting. In other words, (9) holds when \( V_{it} = V_{i}^{h*} \) which is the so-called value-matching condition. But it is not only that the values of the first and second argument of the maximum function in (4) should coincide. A further condition is that the first and second argument of this function have to approach each other tangentially at the threshold value for productivity \( V_{it}^{h*} \) so that

\[
F'(V_{it}) = 1
\] (10)

when evaluated at \( V_{i}^{h*} \), the so-called smooth-pasting condition. In order to derive the threshold productivity value above which it is optimal to invest, we apply the method of undetermined
coefficients and guess that the option value can be represented in the form

$$F(V_{it}) = A(V_{it})^\beta$$  \hspace{1cm} (11)$$

when evaluated at $V_{it}^{h*}$ with $A$ and $\beta$ as constants to be determined. This form of the solution is the only one that is consistent with the fact that $F(0) = 0$ which is implied by the stochastic process defined in equation (1). Once the return to hiring reaches zero, it will stay at zero forever as well as the option value.

The four conditions (8)-(11) determine the solution for $V_{it}^{h*}$. From substituting (11) into (9) and (10), the threshold productivity value can be derived as

$$V_{it}^{h*} = \frac{\beta}{\beta - 1}. \hspace{1cm} (12)$$

Plugging (9) and (12) into (11), we can solve for $A$ as

$$A = \frac{(\beta - 1)\beta^{-1}}{\beta}. \hspace{1cm} (13)$$

If we substitute (11) into (8), we obtain

$$\frac{1}{2} \eta^2 \beta (\beta - 1) - \rho = 0 \hspace{1cm} (14)$$

which can be solved for $\beta$ as

$$\beta = \frac{1}{2} + \sqrt{\frac{1}{4} + \frac{2\rho}{\eta^2}} > 1, \hspace{1cm} (15)$$

where only the positive root is considered, given that $F(0) = 0$. For the threshold productivity value $V_{it}^{h*}$, equation (15) implies that $V_{it}^{h*} > 1$. In order for the firm to hire workers, it does not necessarily suffice that a worker generates more value added than it costs. Instead, workers’ productivity has to exceed its cost by a positive amount, given by equation (12). Because of uncertainty, the return of the project in terms of the net present value of expected future profit flows has to be strictly
larger than the sunk costs in order to make the investment worthwhile. This is the main result of McDonald and Siegel (1986).

Additionally, since \( \rho \) and \( \eta \) are economy-wide parameters, we can drop subscript \( i \) and write the productivity threshold for hiring as

\[
V_i^{\text{h}*} = V^h*.
\] (16)

The productivity threshold above which it is optimal to hire workers is not firm-specific, but valid for all firms in the economy. Taking (12), (15) and (16) together and solving for uncertainty parameter \( \eta \), we can derive

\[
\eta = \sqrt{\frac{2\rho}{V_i^{\text{h}*} - \frac{1}{2}}}. 
\] (17)

Hiring uncertainty in the economy depends on the discount factor and the productivity threshold, above which firms hire workers. When taking this equation to quarterly data, we will for each quarter determine which level of uncertainty is consistent with the data observed in that quarter. Since hiring uncertainty is constant over time in the model and there is no difference between the level of current and future uncertainty, the empirical measure that will be derived for each quarter is forward-looking in nature.

### 2.2 Lay-off decision

Instead of opening up a new project and hiring, a firm also has the option to scrap an existing project and lay workers off, where \( \bar{b}_i \) is the exogeneously given number of workers involved in the project. Laying workers off can be seen as a negative investment. When laying workers off, a firm obtains the wage commitments \( \bar{b}_i \bar{W}_i \) back which can be seen as a return to this investment. However, in exchange it has to relinquish the expected value added \( \bar{b}_i \bar{P}_i \) produced by these workers in the future which is an opportunity cost of laying off workers. For example, assume that the workers would have stayed for one more year working for the firm, but are instead laid off early. Then the wage commitment “saved” by the firm corresponds to the wages that would have been
paid to the workers within this one year, if they had not been laid off. The expected value added is the output that these workers would have been expected to produce in the same period.

Let us define again $V_{it} = \frac{P_{it}}{W_i}$, where $V_{it}$ denotes the expected value added that would have been generated by the workers that are laid off per unit of labour cost. As for hiring, note that $V_{it}$ is independent of project size $\bar{b}_i$, given that labour costs and productivity are assumed to be the same for all workers laid off by the firm. Labour productivity evolves according to the stochastic process defined in equations (1) and (2).

The lay-off decision problem is solved analoguously to the hiring decision problem. The difference is that the firm’s return to project scrapping is now $\frac{1}{V_{it}}$, the inverse of labour productivity. However, as for hiring, the possibility to lay off workers can be seen as an option for the firm. The firm aims at maximizing the expected net present value of this option by choosing the optimal time to lay workers off. The solution consists again of a productivity threshold and the firm will only want to lay workers off if productivity gets below this threshold, denote by $V_{l^*i}$.

The productivity threshold below which firms will lay workers off can be derived as

$$V_{l^*i} = V^{l*} = \frac{\beta - 1}{\beta}$$

where $\beta$ is defined as in equation (15). It should be noted that $V^{l*} = \frac{1}{\sqrt{\eta}}$. Given the definition of $\beta$, $V^{l*} < 1$ is now valid. Only when productivity is lower by a strictly positive amount, given by (18), firms may decide to scrap a project. Hiring uncertainty $\eta$ can then, as alternative to (17), also be expressed as

$$\eta = \sqrt{\frac{2\rho}{\left(\frac{1}{1-V^{l*}} - \frac{1}{2}\right)^2 - \frac{1}{4}}}.$$  

(19)

Note that this value of $\eta$ corresponds exactly to the one in (17). The following section will discuss how equations (17) and (19) are transformed into expressions that can be used to calculate hiring uncertainty on the basis of available data.
3 Taking theory to the data

In the previous section, hiring uncertainty was derived as a function of the productivity thresholds $V^{h*}$ and $V^{l*}$, where one is the inverse of the other. Since it is not obvious which data can be used to measure these productivity thresholds, they need to be expressed as functions of variables for which data are available.

In the economy-wide version of the uncertainty indicator, the productivity thresholds are valid for the whole economy, assuming that firms in an economy apply the same discount factor and perceive the same economy-wide uncertainty. In the sectoral version, the productivity thresholds are sector-specific, assuming that firms in the same sector apply the same discount factor and perceive the same sectoral uncertainty. Whether a firm hires workers, lays them off or does not change the size of its workforce depends on where the firm is located in the productivity distribution across firms in a given moment of time. If a firm’s productivity is below the lower threshold so that $V_d \leq V^{l*}$, then this firm will lay workers off. If it is above the upper threshold so that $V_d \geq V^{h*}$, the firm will hire workers. If it is in between the two thresholds so that $V^{l*} < V_d < V^{h*}$, the firm will leave the number of workers in its workforce unchanged.

So far, we have not modeled the productivity distribution across firms in a given moment of time. The previous section has just defined the stochastic process according to which the productivity of a single firm varies over time with future productivity values being distributed log-normally. However, in reality the productivity in a given point of time varies across firms. Therefore, we consider in this section the hiring and lay-off decisions of multiple firms that are heterogeneous in productivity. On the basis of this extension of the theoretical framework, we can derive the two productivity thresholds $V^{l*}$ and $V^{h*}$ that are needed to calculate hiring uncertainty.

In the absence of firm-level data, the productivity distribution across firms in a given moment of time cannot be observed. Nevertheless the exact distribution can be inferred from available data.

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10Firm-level data exist for many economies, but they often do not cover a representative sample of firms. Moreover, data are not necessarily comparable across countries.
under certain assumptions. In particular, we will need to assume that productivity is distributed log-normally across firms. This assumption is in line with the one made in the trade literature on heterogeneous firms by Melitz (2003) who assumes that firms’ initial productivity is drawn from a distribution with support (0, ∞). There indeed must be a lower threshold of productivity, given that firms with a productivity below such a threshold are forced to exit the market. The productivity of these firms hence cannot be observed. Okubo and Tomiura (2013) find that the productivity of firms located in peripheral regions of Japan is close to log-normally distributed. Dosi et al. (2013) also provide evidence for labour productivity to be distributed close to log-normally across Chinese firms.

Given these findings, assuming that the productivity distribution across firms is log-normal seems sensible. If productivity is distributed log-normally in an arbitrarily chosen point of time \( t \), so that

\[
V_t \sim \ln \mathcal{N}(\mu, \sigma)
\]  

(20)

where \( \mu \) and \( \sigma \) are mean and standard deviation of the natural logarithm of productivity, then it is also distributed log-normally in any other point of time. This is because the stochastic process defined in (1) and (2) is assumed to hold for every firm that is part of the distribution. Consider time \( t + dt \) with \( dt > 0 \). Assume that the Wiener process in (2) has realized the value \( \bar{\epsilon} \) for \( \epsilon_{t+dt} \).

We then know that the productivity for each firm in time \( t + dt \) is a multiple of the productivity for each firm in time \( t \) such that

\[
V_{t+dt} = (1 + \eta \sqrt{dt} \ \bar{\epsilon}) V_t.
\]  

(21)

This result implies that productivity in time \( t + dt \) is also distributed log-normally across firms, given that a multiple of a random variable that is log-normally distributed is still log-normally distributed. The productivity distribution across firms in \( t + dt \) can then be written as

\[
V_{t+dt} \sim \ln \mathcal{N}(\mu, (1 + \eta \sqrt{dt} \ \bar{\epsilon})\sigma).
\]  

(22)
Let us focus now on the arbitrarily chosen point in time \( t \) in which productivity across firms is distributed log-normally as in (20). \( \mu \) and \( \sigma \) are unknown as well as the productivity thresholds \( V_{l}^{i*} \) and \( V_{h}^{i*} \). However, we know that \( V_{l}^{i*} = \frac{1}{V_{h}^{i*}} \) which implies that \( \ln V_{l}^{i*} = -\ln V_{h}^{i*} \), so once we know one productivity threshold, it is straightforward to calculate the other one. On the whole, there hence are three unknown variables.

Assume that we know the share of firms that hires workers and the share of firms that lays workers off and denote these shares respectively by \( sh_{h} \) and \( sh_{l} \). We also know the mean value of productivity \( \bar{V} \). With this information, it is possible to infer the two parameters of the log-normal distribution, \( \mu \) and \( \sigma \), and the productivity thresholds \( V_{l}^{i*} \) and \( \ln V_{h}^{i*} \) respectively. We set up the following three equations:

\[
\ln \bar{V} = \mu + \frac{1}{2} \sigma^2 \tag{23}
\]

\[
F^{-1}(sh_{l}) = \frac{\ln V_{l}^{i*} - \mu}{\sigma} \tag{24}
\]

\[
F^{-1}(1 - sh_{h}) = \frac{-\ln V_{l}^{i*} - \mu}{\sigma} \tag{25}
\]

where \( F() \) is the cumulative distribution function of the standard normal distribution and \( F^{-1}() \) the inverse of it. The mean of a log-normal distribution can be expressed as \( \bar{V} = e^{\mu + \frac{1}{2} \sigma^2} \) and rearranging this equation, we obtain (23). Moreover, \( sh_{l} \) can be seen as the probability of observing a firm with a productivity below threshold \( V_{l}^{i*} \), from which we can derive (24). Similarly, \( sh_{h} \) is the probability of a firm with a productivity above \( V_{h}^{i*} \) from which we obtain (25).

Equations (23)-(25) form a system of equations with three unknowns \( \mu \), \( \sigma \) and \( V_{l}^{i*} \) which can be solved. Rearranging equation (23) and solving for \( \sigma \), while considering that \( \sigma > 0 \), we obtain

\[
\sigma = \sqrt{2 \ln \bar{V} - 2\mu}. \tag{26}
\]

Multiplying (24) and (25) by \( \sigma \) and adding up the left- and the right-hand side of the two equations,
we obtain

\[ (F^{-1}(sh_l) + F^{-1}(1 - sh_h)) \sigma = -2\mu. \] (27)

The expression for \(-2\mu\) in (27) can be plugged into (26) which produces

\[ \sigma = \sqrt{2 \ln \bar{V} + [F^{-1}(sh_l) + F^{-1}(1 - sh_h)] \sigma}. \] (28)

Taking the square on both sides and re-arranging, (28) becomes

\[ \sigma^2 - [F^{-1}(sh_l) + F^{-1}(1 - sh_h)] \sigma - 2 \ln \bar{V} = 0. \] (29)

This equation has a positive and a negative root, given that workers are assumed to produce on average more than they cost such that \(\bar{V} > 1\). Since \(\sigma > 0\), only the positive root is a solution for the standard deviation of the log-normal distribution which can be written as

\[ \sigma = Z + \sqrt{Z^2 + 2 \ln \bar{V}} \] (30)

where \(Z = \frac{F^{-1}(sh_l) + F^{-1}(1 - sh_h)}{2}\). Solving (23) for \(\mu\) and plugging in \(\sigma\), we obtain for the expected value of the log-normal distribution

\[ \mu = \ln \bar{V} - \frac{1}{2} \left[ Z + \sqrt{Z^2 + 2 \ln \bar{V}} \right]. \] (31)

Plugging (30) and (31) into (24) and re-substituting \(\ln V_i^{L*}\) for \(X\), we obtain the productivity thresholds

\[ V_i^{l*} = e^{\ln \bar{V} + (F^{-1}(sh_l) - \frac{1}{2}) \left( Z + \sqrt{Z^2 + 2 \ln \bar{V}} \right)} \] (32)

\[ V_i^{h*} = e^{-\ln \bar{V} - (F^{-1}(sh_l) - \frac{1}{2}) \left( Z + \sqrt{Z^2 + 2 \ln \bar{V}} \right)} \] (33)

Having derived these productivity thresholds, we can plug them into equation (19) to derive the
following expression for hiring uncertainty:

\[
\eta = \sqrt{\frac{2\rho}{\left[1 - e^{\ln \bar{V} - \left(F^{-1}(\text{sh}) - \frac{1}{2}\right)(Z + \sqrt{Z^2 + 2\ln \bar{V}})^{-1} - \frac{1}{2}\right]^2}}.}
\]  

(34)

Assuming a time-constant value for \( \rho \) which then acts as a shifter of uncertainty, it is possible to calculate hiring uncertainty \( \eta \), using readily available data. To calculate uncertainty for a whole economy, we will need data on average productivity and the respective shares of firms that hire workers and lay workers off. Deriving sector-specific measures of uncertainty is also possible, provided we have data on sector-specific productivity as well as sector-specific information on hires and lay-offs.

4 Data

The data utilized to calculate economy-wide hiring uncertainty for G7 economies and sectoral hiring uncertainty for manufacturing and construction in the United States is described in the following.

4.1 Share of firms that hire workers and lay workers off

Data on the hiring intentions of firms are taken from the Manpower Employment Outlook Survey.\(^{11}\) This survey is based on interviews with more than 66,000 employers across 42 countries and territories and is designed to be representative of each economy. Survey results are available for an economy as a whole as well as by economic sector, where sector definitions vary across countries. The survey is conducted quarterly and consists in asking private and public employers how they anticipate employment at their location to change in the next quarter. Employers indicate whether they intend to increase or decrease the number of employees in their workforce. Alternatively, they

can reply that they do not expect any change or that they do not know.

On the basis of the information available, the ManpowerGroup, a temp work agency that conducts the survey, calculates a Net Employment Outlook which corresponds to the difference between the percentage of employers anticipating an increase in their workforce and the percentage of employers anticipating a decrease. However, this indicator, calculated in the above-mentioned manner, does not suffice as an input to the hiring uncertainty indicator that is defined in equation (34). In contrast, we need the individual components of this index, so we require $sh_l$ and $sh_h$, which are the respective shares of firms that intend to lay workers off and hire workers. The Manpower Employment Outlook Survey collects exactly this information.

From this survey we use data on the economy-wide share of firms that anticipate an increase in their workforce and the economy-wide share of firms that anticipate a decrease for G7 countries. For most of these countries, data are available from 2006 Q1 until 2013 Q3, for Japan from 2003 Q3 until 2013 Q3. Additional data on the Net Employment Outlook as calculated by the ManpowerGroup are available to us for the period before 2006 also for other countries than Japan. However, these are only data on the difference between the percentage of employers that anticipate an increase and the percentage that anticipate a decrease in their workforce, not on the percentages itself. In order to not waste this information, we impute the individual percentages for the period before 2006 on the basis of the assumption that the share of firms that intends to leave the size of its workforce remains unchanged at its mean value. Indeed, when available, we do not observe much variance in this share, so we are likely to do reasonably well when assuming this share to be constant. For the United States, Canada and the United Kingdom, we end up with a data series on economy-wide hiring intentions starting from 1992 Q1. For Japan, France, Germany and Italy, the starting date is 2003 Q3.

In addition, we use data on the sectoral shares of firms that anticipate an increase in their workforce and the sectoral share of firms that anticipate a decrease for the United States. These data are available for 13 sectors for the period from 2006 Q4 until 2013 Q3. Given the limited data availability
for productivity, we end up using data on hiring intentions for manufacturing and construction only. These data series enter as an input into a sectoral hiring uncertainty indicator for the United States, calculated on the basis of equation (34).

4.2 Productivity

The other main ingredient to the hiring uncertainty indicator defined in (34) is average labour productivity $\bar{V}$. Productivity is defined as output per unit of labour cost. This is exactly the inverse of unit labour cost defined as labour costs per unit of output.

Quarterly data and estimates on economy-wide output and labour costs for 1992 Q1 to 2013 Q3 are taken from the Organization for Economic Co-operation and Development (OECD) that reports data for G7 economies. The OECD also reports quarterly data on sectoral output and labour costs in the United States for 2006 Q4 to 2011 Q3. Data are available for manufacturing and construction. Productivity is calculated as the ratio of output and labour costs. Before using productivity as an input to the uncertainty indicator, it is detrended by deducting the predicted value of a regression of productivity on time and its square. This is because the return to hiring is assumed to not follow any trend in the theoretical model. For each country and sector, we then normalize the data series in such a way that detrended productivity equals actual productivity in the first quarter of 2006.

5 Hiring uncertainty: Indicator results

5.1 Hiring uncertainty in G7 economies

Hiring uncertainty calculated according to equation (34) is shown in Figures 1-7 for G7 economies. The hiring uncertainty indicator is directly compared to the policy uncertainty indicator of Baker

\[\text{Current work focuses on broadening the available base of data, so that the indicator can be calculated for a wider range of sectors.}\]
et al. (2013) in all countries except Japan, for which policy uncertainty is not available. For now, we assume the discount factor to be constant at a level of 0.1 for all countries.\footnote{In future work, we are planning to relate the discount factor to the long-term interest rate.} The choice of a different discount factor that is constant over time will simply shift the uncertainty indicator upward or downwards, but does not have an impact on the fluctuations of uncertainty over time.

Figure 1: Hiring uncertainty in the United States

![Graph showing hiring uncertainty in the United States](image)

Note: Chart compares hiring uncertainty to the policy uncertainty indicator of Baker et al. (2013). Time discount factor is set to 0.1.
Source: Authors’ calculations; Baker et al. (2013).

Hiring uncertainty in the United States, shown in Figure 1, remained at a broadly constant level before the Great Recession with a modest peak in 2001-2003, following the burst of the dot-com bubble and the September 11 terrorist attacks, which is also in line with the trends observed for policy uncertainty. In the end of 2007, when the Great Recession began, uncertainty has virtually jumped upwards and it has remained at high levels since then, decreasing only slowly. The decrease in hiring uncertainty is slower than the decrease in policy uncertainty that recently went back to levels observed in 2001-2003. While productivity has got back to pre-crisis levels in the meanwhile,
hiring demand has not, which in the given theoretical framework is interpreted as evidence for elevated uncertainty.

Figure 2: Hiring uncertainty in Canada

![Graph showing hiring uncertainty in Canada](Image)

Note: Chart compares hiring uncertainty to the policy uncertainty indicator of Baker et al. (2013). Time discount factor is set to 0.1.

Source: Authors’ calculations; Baker et al. (2013).

As shown in Figure 2, hiring uncertainty in Canada exhibited trends that are similar to those observed for the US. The only main difference seems that uncertainty in the beginning and mid of the 1990s was at a relatively high level in Canada which was not observed in the United States. However, the Canadian economy has seen four years of GDP growth of above 4 per cent between 1997 and 2000, which likely brought down uncertainty until the onset of the Great Recession.14

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14These data on GDP growth rates are taken from World Bank.
In France, uncertainty jumped up in 2008, as illustrated in Figure 3. There have been strong fluctuations in uncertainty since then, but the level of uncertainty remains elevated.
Even though uncertainty is not any more at its peak in the United Kingdom, as shown in Figure 4, it still is at a relatively high level compared to before the crisis. Only at the beginning of the data series, in 1992, uncertainty was at a similar level as currently. This was the last year of the beginning of the 1990s recession in the United Kingdom. Generally, it is remarkable particularly for the United Kingdom how similar the variations of hiring uncertainty and policy uncertainty are.
In Germany, the pattern of hiring uncertainty differs from what is observed in other countries, as shown in Figure 5. Uncertainty has been on a downward trend since 2003, only interrupted by relatively small jumps upwards during the Great Recession. This trend is in line with the trend in unemployment which has been declining in the last decade, even during the Great Recession. However, the ups and downs of the series around the trend closely track the variations in policy uncertainty.

Note: Chart compares hiring uncertainty to the policy uncertainty indicator of Baker et al. (2013). Time discount factor is set to 0.1.

Source: Authors’ calculations; Baker et al. (2013).
Uncertainty in Italy has, as in most countries, increased in 2008, as Figure 6 shows. However, it has come back to lower levels in 2011, before rising again until recently.
Figure 7 illustrates uncertainty in Japan which starts from a very high level in 2003, decreasing sharply until the onset of the Great Recession, before again jumping upwards to high levels in 2008 and 2009. However, in contrast to the trends observed for Canada and US, uncertainty in Japan declined again to a relatively low level between 2009 and 2013.

The question arises whether uncertainty is also comparable across countries. First, we used the same discount rate for all G7 economies. In order to insure comparability across countries, this assumption needs to hold true in reality in order for uncertainty to be comparable across countries, which is somewhat difficult to verify. However, if the discount factor is assumed to be not the same, but at least similar across countries, results arguably should give a broad idea about the ranking of countries in terms of uncertainty. Second, the data that is used as an input into the uncertainty indicator has to be comparable across countries. The data on the share of firms that hires and lays off workers from the *Manpower Employment Outlook Survey* is comparable across countries, given
that it is derived from a survey in which the same question is asked in all countries. Also the data
on productivity, calculated as the inverse of unit labour costs, can be compared across countries,
according to the data description by OECD. In summary, we therefore believe that our uncertainty
indicator can at least to some extent be used for a cross-country comparison.

Hiring uncertainty is currently at very similar levels in the United States and the United Kingdom.
In Germany and Canada, hiring uncertainty is higher than in these two countries. In France, Italy
and Japan, hiring uncertainty is the highest in the cross-country comparison for 2013.

5.2 Hiring uncertainty by sector in the United States

Sectoral hiring uncertainy in the United States, calculated for manufacturing and construction, is
shown in Figures 8-9. Once more, we assume the discount factor to be constant at a level of 0.1 in
all sectors.

Figure 8: Hiring uncertainty in manufacturing, United States

Note: Time discount factor is set to 0.1.
Source: Authors’ calculations.
Hiring uncertainty in the manufacturing sector, as shown in Figure 8, broadly follows the trends observed in economy-wide uncertainty. Uncertainty in manufacturing went up at the onset of the Great Recession and was on a declining trend between mid of 2009 and 2011. In contrast to the economy-wide indicator, however, hiring uncertainty in manufacturing went down much stronger, almost reaching pre-crisis levels already in 2011.

Figure 9: Hiring uncertainty in construction, United States

Note: Time discount factor is set to 0.1.
Source: Authors’ calculations.

Hiring uncertainty in the construction sector, shown in Figure 9, was trending upwards between 2007 and 2011, the whole period for which the indicator is available. Only in 2007 and 2011, there were few quarters in which uncertainty did not increase. The upward trend in uncertainty within the construction sector is consistent with the many jobs lost in that sector during the crisis.
6 How does hiring uncertainty affect growth and jobs?

Hiring uncertainty is expected to have an effect on employment dynamics, separate and distinct from overall macroeconomic conditions such as output growth. The heightened uncertainty that companies face on labour markets will make them reluctant to open new vacancies and give them incentives to shed more workers, thereby pushing up unemployment rates. At the same time, higher hiring uncertainty is an indication of a generally weak macroeconomic environment, holding back companies’ investment and thereby lowering GDP growth. In this section, we analyse the importance and pass-through of this effect and compare it with effects such as those generated by policy uncertainty.

The analysis of the uncertainty pass-through is based on a 3-variables vector-autoregression system as follows:

\[
\begin{pmatrix}
  \text{Gap}_{t,j} \\
  \text{Unr}_{t,j} \\
  \text{Uncertainty}_{t,j}
\end{pmatrix}
= \sum_{i=1}^{4}
\begin{pmatrix}
  \text{Gap}_{t-i,j} \\
  \text{Unr}_{t-i,j} \\
  \text{Uncertainty}_{t-i,j}
\end{pmatrix}
+ \alpha_j + \varepsilon_{t,j}
\]

where \( \text{gap}_t \) : the output gap measured using HP-filtered GDP growth, \( \text{Unr}_t \) : the (HP-filtered) unemployment rate, \( \text{Uncertainty}_t \) : our preferred measure of hiring uncertainty as discussed in the previous section and \( \alpha \) : a constant/fixed effect. We use quarterly data and a lag structure of the last 4 quarters. The VAR is estimated for each of our seven economies individually (hence dropping the country index \( j \)) as well as in a panel, using \( \alpha_j \) fixed effects to distinguish between the countries. The following figure 10 gives an overview of the sum of coefficients for the different estimated equations both for the panel and for individual countries.

As the figure indicates, all coefficient sums have the expected signs - hiring uncertainty lowers output and increases unemployment - but with variations in the quantitative importance for individual countries and in comparison to the panel as a whole. The results are robust to changes in specification such as a change in the number of lags or the use of alternative measures of GDP and employment - e.g. using GDP growth rather than the output gap or using employment growth...
Figure 10: Summary of VAR results

Note: The chart displays the result of a 3x3 VAR including the output gap, the unemployment rate and the ILO hiring uncertainty index. The VAR includes four lags of each variable. The size of the pies correspond to the sum of the coefficients, a red pie indicates a negative sum, a blue pie stands for a positive sign.
Source: ILO Hiring uncertainty indicator; OECD Economic Outlook database 94; own calculations.
rather than the unemployment rate. In contrast, using alternative measures of uncertainty - such as the policy uncertainty index by Baker et al. (2013), or a measure of implied volatility on the labour market - can substantially change the results of the estimation, at least for individual countries if not for the panel overall.\textsuperscript{15}

To further analyse the pass-through and better understand how hiring uncertainty affects the labour market, we added more detail to the above model using the ILO’s Quarterly Labour Flows database. This allowed us to differentiate between unemployment inflows - a proxy measure for job destruction - and unemployment outflows - a proxy measure for job creation - in the above VAR:

\[
\begin{pmatrix}
\text{Gap}_{t,j} \\
\text{UnInflows}_{t,j} \\
\text{UnOutflows}_{t,j} \\
\text{Uncertainty}_{t,j}
\end{pmatrix} = \sum_{i=1}^{4} \begin{pmatrix}
\text{Gap}_{t-i,j} \\
\text{UnInflows}_{t-i,j} \\
\text{UnOutflows}_{t-i,j} \\
\text{Uncertainty}_{t-i,j}
\end{pmatrix} + \alpha_j + \varepsilon_{t,j}
\] (35)

where instead of the unemployment rate we now distinguish between \(\text{UnInflows}_{t}\) : the unemployment inflows and \(\text{UnOutflows}_{t}\) : the unemployment outflows. As in Ernst and Rani (2011), we assume that unemployment inflows and outflows are not independent from each other but rather exercise a mutual influence. The shock pass-through is now analysed by imposing a structure on the shock structure, using a Choleski decomposition of the error matrix. Using the above ordering of the variables, we assume that hiring uncertainty is the most exogenous shock, whereas the output gap is the most endogenous one. The corresponding SVAR then yields the following impulse-response function(s) for the four different shocks, differentiating between country-individual estimations and the panel as a whole. As figure 11 demonstrates, hiring uncertainty has a strong effect on the output gap but which runs only partially through changes in unemployment outflows. Rather, it is unemployment inflows, i.e. job destruction, that are most affected by shocks to hiring uncertainty (panel 4). On the other hand, shocks to unemployment outflows reduce hiring uncertainty for an

\textsuperscript{15}For an overview of the VAR results using different uncertainty measures see the figures in the annex section. Detailed regression results of the base specification and alternative indicators and set-ups are available from the authors upon request.
extended period of time (up to 10 quarters), at least when the panel as a whole is considered (panel 3). Finally, demand shocks such as those that drive the output gap have strong, but short-lived effects on hiring uncertainty as much as they influence the dynamics on the labour market directly (panel 1).

Figure 11: Impulse-responses with structural shocks

Note: The chart displays the impulse-response functions for the four structural shocks based on equation (35). The four shocks are #1: a shock on the output gap, #2: a shock on unemployment inflows, #3: a shock on unemployment outflows, #4: a shock on hiring uncertainty.

7 Conclusion

This paper derives a measure for the macroeconomic uncertainty that employers are confronted with when taking decisions about the size of their workforce. As theoretical framework, the paper adapts the investment model of McDonald and Siegel (1986) to the context of hires and lay-offs and interprets employers’ changes in the size of the workforce as investment decisions. Employers
have to decide when to hire or layoff workers. The result of the model indicates that the expected return to hiring needs to be strictly larger than the costs in order to make it optimal for employers to hire at a given point of time. The size of the difference between the expected return and the costs depends on the level of uncertainty in the market. Based on the model, we can derive two productivity thresholds that mark the levels of labour productivity above which firms hire workers and below which firms lay workers off.

Assuming productivity to be distributed log-normally across firms, we then derive uncertainty as a function of the shares of firms that intend to hire workers and lay workers off as well as the average labour productivity in the economy or sector. Using data on average labour productivity from OECD and on firms’ hiring and lay-off intentions from the ManpowerGroup, we calculate uncertainty indicators for G7 countries as well as sectoral uncertainty for the United States. For most countries, hiring uncertainty follows quite similar trends as the policy uncertainty indicator of Baker et al. (2013), which gives us some confidence in the validity of our approach. However, there also differences which remain to be examined in more detail.

Our hiring uncertainty indicator displays important correlation with both unemployment and the output gap, over and above the direct link between labour market and demand variables. Our indicator is robust to specification changes and shows more regularity in its impact across countries than alternative uncertainty indicators. A more detailed analysis of the pass-through of uncertainty shocks reveals that job destruction is a key channel through which hiring uncertainty affects labour market dynamics and the output gap.

Future work will also focus on a broadening of the indicator coverage with respect to countries and economic sectors. In particular, we aim at developing a measure for hiring uncertainty also for emerging and developing economies, which should be feasible for some countries, given that data on hiring intentions and unit labour costs are available. Moreover, we intend to examine the factors that have an impact on hiring uncertainty and analyze the role that hiring uncertainty can play to improve unemployment forecasts.
References


Annex figures

Figure 12: Summary of VAR results: Policy uncertainty

Note: The chart displays the result of a 3x3 VAR including the output gap, the unemployment rate and Baker’s policy uncertainty index. The VAR includes four lags of each variable. The size of the pies correspond to the sum of the coefficients, a red pie indicates a negative sum, a blue pie stands for a positive sign. Source: Baker et al. (2013); OECD Economic Outlook database 94; own calculations.
Figure 13: Summary of VAR results: Implicit volatility

Note: The chart displays the result of a 3x3 VAR including the output gap, the unemployment rate and the ILO implicit labour market volatility index. The VAR includes four lags of each variable. The size of the pies correspond to the sum of the coefficients, a red pie indicates a negative sum, a blue pie stands for a positive sign.
Source: ILO Implicit labour market volatility : OECD Economic Outlook database 94; own calculations.