Policy Uncertainty and Misallocation in Brexit UK

Renato Faccini  
Queen Mary, University of London, and Centre for Macroeconomics (LSE)*

Edoardo Palombo  
Queen Mary, University of London†

March 23, 2018‡

Abstract

Announcements of large-scale economic reforms that affect resource misallocation generate (i) uncertainty about the timing of implementation (ii) and aggregate uncertainty about productivity in the long-run. Using a variant of the neoclassical growth model, we disentangle the short-run effects of these different sources of uncertainty around the reforms, from the long-run effects of their actual implementation. Specifically, we consider announcements of distortionary economic reforms, which produce dynamics around an initial steady-state without distortions, and, depending on the precise implementation of the reforms, a subsequent transition to a new steady state with distortions. In the quantitative analysis, the model is calibrated to the UK economy in order to study the consequences of Brexit.

Keywords: news, uncertainty, disasters, financial frictions, growth models, firms heterogeneity, productivity, populism, policy distortions.

JEL codes: E21, E22, E44

*Email: r.faccini@qmul.ac.uk
†Email: e.palombo@qmul.ac.uk.
‡We are very grateful to Tatsuro Senga for his comments and suggestions.
1 Introduction

A major advance in the growth literature of the last twenty years is the enhanced recognition of
the importance of resource misallocation as a determinant of productivity in the long run (see
Jones (2011) and Restuccia and Rogerson (2013)). The idea is that the level of aggregate TFP in
a country might depend to a large extent on how efficiently, or inefficiently, the inputs of pro-
duction are allocated across establishments. Importantly, there has been enhanced appreciation
of the role of policy in affecting the efficient allocation of resources. By tackling misallocation,
policy may matter a great deal for the growth prospects of a country (Buera and Shin (2013)).

The interest of this paper is to study the macroeconomic effects of policy uncertainty, in a
structural framework where economic policy matters for the efficient allocation of resources
and thereby for economic growth. The event that motivates this study is the decision of the
United Kingdom to exit the European Union following the EU referendum of June 2016: Brexit.
We argue that the EU referendum results can be interpreted as an announcement of an uncer-
tain large-scale reform that will be implemented in the future.

The growth literature has demonstrated how large-scale reforms can reallocate resources in
order to impact long-run productivity and growth in transition. Brexit is likely to impact the
how resources in the UK economy are allocated. Specifically, Brexit could reallocate resources
resources through: the introduction of tariffs, customs costs, non-tariff barriers, migration con-
trols, disruption of the international supply chains, reduced foreign direct investment as well as
from the introduction of industrial policies targeted at subsidizing economic sectors of strategic
importance. We review the separate channels whereby Brexit may induce resource misalloca-
tion in Section 2. As such, Brexit can be viewed as a large-scale reform which will impact the
UK’s future growth and productivity in the long-run.

Figure 1 shows that Brexit has sparked an incredible amount of uncertainty; at the time of
writing the Economic Policy Uncertainty index is higher than it was at the time of the great
recession or during the two episodes of the Eurozone crisis. But what is this uncertainty about?
We see policy uncertainty as deriving from the following two major sources. First, there is
timing uncertainty on the implementation of the reforms: from the time of the referendum
until the agreements take effect, it will take no less than three years and possibly more than
ten years if transitional arrangements are agreed upon. Second, uncertainty about the shape
of Brexit. As it is unclear whether Brexit means the UK’s exit from the customs union - the
so-called hard Brexit scenario entailing high distortions and low aggregate productivity - or
some form of participation - the so-called soft Brexit scenario entailing mild or no distortions
and high productivity.

In order to quantify the effects of the aforementioned sources of uncertainty, we build
on the framework proposed by Buera and Shin (2013), which is a neoclassical growth model
augmented with firms heterogeneity in both taxes and entrepreneurial ability (productivity).
Specifically, firms face an exogenous process of idiosyncratic taxes and subsidies that distort
production decisions across establishments. This simple approach to modelling misallocation
was pioneered by Restuccia and Rogerson (2008), and subsequently followed by Hsieh and
Klenow (2009), and Bartelsman, Hallienger, and Scarpetta (2013). In all these studies, such
idiosyncratic distortions should not be thought of literally as taxes and subsidies; rather, they
are meant to capture in a parsimonious way all those policies and regulations, including tariffs,
non-tariff barriers, industrial policies and obstacles to competition that generate distortions in
the allocation of resources across firms. In addition, the model features financial frictions, in
the form of a collateral constraint. As shown by Buera and Shin (2013), this modeling feature
has proved successful in generating a speed of convergence that is close to empirical estimates,
thus overcoming a well-known flaw of the standard neoclassical growth model.
Buera and Shin (2013) have used this set-up to investigate the implications of an unexpected once-and-for-all elimination of all taxes and subsidies; this exercise was designed to quantify the effects of large-scale reforms in the miracle economies. Technically, Buera and Shin (2013) shock the pre-reform stochastic steady-state of an economy with distortions and compute the transition path of the endogenous variables to the new steady-state with no distortions. The removal of all taxes and subsidies in the presence of financial frictions implies that the economy slowly converges to a new steady state with endogenously higher productivity. The higher productivity is a result of previously taxed ‘competent’ (high productivity) individuals entering the production process and the exit of previously subsidized ‘incompetent’ (low productivity) individuals. The slower convergence arises as entry and exit in the production process are not instantaneous: ‘competent’ but asset-poor individuals need to accumulate enough wealth to overcome the collateral constraint in order to become entrepreneurs; whilst ‘incompetent’ individuals are slow to exit production as their wealth enables them to be able to compete in the market.

We extend this framework in order to specifically capture the effects of an announcement of the introduction of idiosyncratic taxes and subsidies that will take place at some future date. In the quantitative exercise, this will be interpreted as the effect of the UK referendum to leave the EU. This set-up will allow us to investigate the effects of the news from the time of the announcement until the reforms are actually implemented and then all the way to the new steady-state. In order to investigate the effects of uncertainty surrounding the news, we will then contrast different types of announcements. In the case of perfect information, the news (referendum) will be modeled as an announcement that after a specified number of periods, some firms will be taxed and other subsidized, communicating exactly which firms will be taxed, which will be subsidized, and by how much. This will offer a benchmark for the behavior of the macro economy in the case of no-uncertainty around the consequences of the reforms. We will then contrast the results produced by this benchmark scenario with the case where Brexit is a stochastic event driven by a Poisson process, and firms face idiosyncratic and aggregate uncertainty on the conditions of Brexit. By idiosyncratic uncertainty we mean that firms do not know whether they will be taxed or subsidized after Brexit, and by aggregate uncertainty we mean that there is uncertainty about the distortions introduced by Brexit, which will be large if Brexit is hard, and small if Brexit is soft. Comparing the evolution of the aggregate economic variables under different scenarios of imperfect vs. perfect information will allow us to isolate the effects of different types of uncertainty and the possible interplay between them.

The paper is connected to a number of literatures. It is closely related to the literature on uncertainty, sparked by the seminal work by Bloom (2009). The focus of this literature is on uncertainty shocks, which are modeled as temporary shocks to the second moment of an exogenous TFP process, be it at the aggregate or firm level or both. The nature of uncertainty, in this context, is about the realizations of technology shocks at business cycle frequencies, and is typically interpreted as uncertainty on the states of idiosyncratic and aggregate demand over the very short run. In our model we endogenize the evolution of TFP as arising from the once-and-for-all introduction of distortions to the competitive allocation. Unlike the standard approach towards modeling uncertainty, until Brexit actually takes place there will be no change in the exogenous determinants of TFP, neither at the firm level nor in the aggregate. That it to say, there will be no change in the fundamentals (the policy distortions), and no change in the associated stochastic steady state; after the reforms are implemented the steady state shifts, and the economy will experience a deterministic transition to this new stationary equilibrium. In

\[ \text{See also Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012), Baker and Bloom (2013) and Bloom, Wright, and Barrero (2016).} \]
this set-up uncertainty lasts from the date of the referendum until Brexit takes place, and it is about the timing of the reforms, about idiosyncratic outcomes and about the long-term consequences for aggregate productivity. In this case, uncertainty is about the states of idiosyncratic and aggregate supply of the economy at some point in time and in the long-run.

The paper is also related to work on news shocks, which are defined as the arrival of information that is useful for predicting future fundamentals but does not affect current fundamentals. Important contributions include the work by Cochrane (1994), Beaudry and Portier (2004), Beaudry and Portier (2007), Jaimovich and Rebelo (2009) and Barsky and Sims (2009). In these models, the interest is on the impact of a sequence of temporary shocks to the future level of TFP, in a business cycle context. In our framework the interest is on one news of a large-scale reform that will affect permanently and endogenously the steady-state level of TFP via its effects on resource misallocation.

The paper also relates to the literature on economic disasters, which are rare economic events, typically modeled as the realization of an exogenous stochastic process, that entails a sudden destruction of physical capital (see Gourio (2013)). Also in this literature the focus has been on business cycle dynamics, namely how a time-varying probability of disasters can affect the behavior of the macro-economy at high frequencies. In our set-up we are interested in the short- and long-term effects of announced economic ”disasters”, which arise endogenously as the outcome of policies that, by inducing capital misallocation, generate a reduction in the level of capital in the long run.

Summing up, because we are interested in the effects of news and uncertainty about possible economic ”disasters”, our study necessarily connects to the three strands of literature outlined above. But because the notion of economic disaster that is relevant here is the long-run consequence of large-scale, distortionary economic reforms, our analysis cannot be cast within the confines of a standard business cycle model. Rather, it requires shifting the analysis of news, uncertainty and disasters within the framework of a neoclassical growth model, where the announcement of economic reforms produces dynamics around an initial steady-state without distortions, and, depending on the precise implementation of the reforms, a subsequent transition to a new steady state with distortions. In this context, short- and long-term dynamics are manifestation of the same economic phenomenon - the reforms - and should therefore be studied within the same modeling framework.

Although our study is motivated by Brexit, we see our contribution as going beyond the analysis of this important event. This paper offers a general framework to quantify the effects of uncertainty related to the future implementation of large-scale reforms that potentially matter for economic growth by affecting resource misallocation. The model captures two important features of any such policy reforms. The first is that it takes time to turn political statements into effective decisions, and the second is that there is uncertainty around both the precise terms of any political agenda and the exact timing of its implementation. The model allows us to disentangle the short-run effects of uncertainty about the reforms from the long run effects of the actual reforms. As such, it is also suitable to study the effects of uncertainty about political elections where some electoral outcomes may severely affect the efficient allocation of resources.

The next Section presents the model. We will then describe the experiment, the calibration, and the results.

2 Brexit and misallocation

Recent speeches from the UK Prime Minister, Theresa May, signaled the possibility of ”a Hard Brexit” - leaving the Single Market without a replacement deal in place. ”No deal is better than
a bad deal” has been one of the key messages sent by the UK to the EU diplomats midst the Brexit negotiations. A “no deal” scenario would entail reverting to WTO rules, severing all formal ties with the EU. In practice, this would imply a disruption in the free movement of goods, capital, services, and labour across EU member states, the so called “four freedoms”. We review below various channels through which the disruption of such freedoms is likely to increase resource misallocation in the UK economy.

**Tariffs and quotas** - As of 2014, the Office of National Statistics calculated that exports towards the EU amount to 13% of UK’s GDP, which is 45% of the UK’s overall exports; imports from the EU comprise 53% of total imports. Evidently, the most obvious channel through which Brexit can introduce resource misallocation in the UK economy is though the disruption of free trade. The UK and the EU have benefited from a free trade agreement since 1973. The agreement stipulated meant that the two blocks could trade with out any tariffs, quotas, or barriers. According the the White Paper published by the UK government in accordance to the start of the Brexit negotiations, the UK will not be seeking access to the Single Market. If free trade with the EU will end, importers and exporters of EU goods and services would face tariffs and potentially also quotas.

Disruption to the free movement of good and services introduces a key source of resource misallocation. Tariffs, quotas, and barriers to trade act as a tax on importers and exporters and as a subsidy to domestic firms which fully operate with the UK’s border. A well established empirical literature in trade has demonstrated that firms that trade outside the nation’s boundaries tend to be larger and more productive. Thus, disrupting free trade will result in misallocation of resources, benefitting smaller and less productive firms at the expense of larger and more productive firms. In fact, any agreement besides full access to the Single Market will increase resource misallocation in the UK economy.

**Regulation** - Many important industries of the UK economy, like the pharmaceutical and automotive industry, are subject to heavy regulations across the world. This means when the UK comes to sell these products in the world markets, it has to comply with the industry regulations in the country where the product is sold in. One advantage of the EU membership is that the regulatory framework imposed complies with most of the world’s regulation. For example, the Confederation of British Industry (CBI) has warned that due to the high regulatory frameworks, pharmaceutical and plastic businesses “are seeking regulatory stability and certainty”. In this regard, The CBI has pointed out that the EU regulation in manufacturing has helped simplify trade by harmonizing production standards. SIZE OF SECTORS By leaving the EU and having its own regulatory system, the UK risks its goods “getting stuck in tiresome market approval processes”. As a result, ceasing to conform to the EU regulatory system may result in an implicit tax to UK exporters, which would in turn induce resource misallocation. This implicit tax would be prohibitively high for products that cannot be traded unless they adhere to specific EU regulations. Furthermore, since the EU regulation are recognized worldwide, the regulation void produced by a hard-Brexit might also affect exports towards non-EU countries.

**Immigration** - One of the hot topics of the EU referendum has been surrounding immigration.
tion controls. EU membership comes with full compliance of the freedom of movement across EU countries, which means that EU citizens can freely work and live in the member states. Following Brexit the UK government declared its willingness to end the free movement of labour in the Brexit White paper\(^8\) which can produce skill shortages in the UK economy. As evidenced by the EU migration in sectors such as the care sector (NHS), finance, and agriculture, the UK heavily relies on EU migrants in certain industries\(^9\). Imposing controls on EU immigration would exacerbate skill-mismatch in various sectors, as the government cannot identify the type of workers that firms in the UK need better than the firms themselves. As a result, shortages of workers would increase business costs\(^10\) implicitly taxing those sectors that rely the most on the EU labor input.

**International supply chains** - As it stands many large corporations with UK domicile operate across the EU with highly integrated supply chains. The introduction of trade barriers will hinder these international supply chains driving up supply costs for more productive industries. Apart from direct transaction costs, trade barriers may include increased lead times for production, higher inventories, increase administration costs, and lower viability of EU supply chain hubs\(^11\). The effect of trade barriers on the international supply chains is akin to a tax on multinational firms, as they will lose competitiveness to the benefit domestic firms. As such, disruption to these supply chains can misallocate resources from more productive multinational firms to less productive domestic counterparts, as the former are forced to either scale back production or to reduce productivity through reallocation of the supply chain\(^12\).

**State aid** - Market distortions following Brexit are not solely driven by disruptions to the four freedoms. Brexit might induce resource misallocation also by propping-up the scale of government intervention. In fact, the potential use of state aid to provide assistance to its industries has been identified in a Green Paper by the UK government as one of the main opportunities of Brexit\(^13\). Currently, EU membership prohibits governments from favoring domestic industries at the expense of EU competitors\(^14\). Such regulation ensures that the EU markets are competitive and as free from distortions as possible. Nevertheless, should the UK leave the EU with no formal trade agreement, then “no form of State Aid controls would apply to the UK Government, and it would be free to provide any assistance to industries”\(^15\). Assistance could come literally in the form of subsidies to domestic industries or taxes on foreign competitors, though not limited to this. Naturally, any policy which would advantage the domestic producers over the foreign ones is regarded as state aid and can potentially introduce distortions and resource misallocation in UK economy.

## 3 Model

We build a model that is suitable to study the effects of uncertainty over policies that affect resource misallocation. In the model, misallocation derives from individual production wedges, as in Restuccia and Rogerson (2008) and Buera and Shin (2013). Policy uncertainty is related both to the size of the wedges, i.e. the level of distortions, and to the precise timing of policy

\(^{8}\)“The United Kingdom’s exit from and new partnership with the European Union”, HM Government, February 2017, p.25

\(^{9}\)“Making the most of Brexit” - Demos, March 2017, pp.19-23

\(^{10}\)“Making the most of Brexit” - Demos, March 2017, pp.20

\(^{11}\)“Supply Chain: Your Brexit Competitive Advantage” - Price Waterhouse Cooper, February 2017

\(^{12}\)A wide literature has shown that multinational firms which rely on international supply chains tend to be more productive. ADD REFERENCES

\(^{13}\)“Industrial Strategy” Briefing Paper, Number 07682, 31 Jan 2017. p.15

\(^{14}\)http://ec.europa.eu/competition/state_aid/overview/index_en.html

\(^{15}\)“Industrial Strategy” Briefing Paper, pg. 15
implementation. In the case of Brexit there is substantial uncertainty on both. Depending on the precise outcome of the negotiations, Brexit might end-up being hard or soft. We view these alternative options as associated to different levels of distortions to the competitive allocation of resources. Furthermore, the precise timing of Brexit is unknown. Brexit could happen a couple of years after triggering the article fifty clause if negotiations fail at early stages, or it could take several more years if transitional arrangements are agreed upon. In the latter case, negotiations could possibly last for a decade or more, but could also fail at any time, depending on the developments of political circumstances. We explicitly model these two sources of uncertainty building upon the framework proposed by Buera and Shin (2013), which is a neo-classical growth model augmented with heterogeneity in both entrepreneurial talent and assets and with collateral constraints.

3.1 The set-up

The agents - The economy is populated by a unit measure of infinitely-lived agents, indexed by $i \in \{0, 1\}$, who differ in entrepreneurial ability ($e$) and wealth ($a$). The evolution of wealth over discrete time ($s$) arises endogenously as the outcome of an optimal intertemporal decision over consumption and savings. The evolution of individual ability is governed instead by an exogenous Markov stochastic process: in every period, agents retain their ability with probability $\psi$, and with the complement probability take a new draw from the probability density function $g(e)$, where $e$ is a discrete random variable. This draw is independent of the previous ability level. Having observed their ability, every period agents decide whether to work as labourers in exchange for the competitive wage $w$, or become entrepreneurs and receive the profits from production $\pi(e)$. This optimal choice, which solves a static problem, implies working in the occupation that yields a higher return. Agents also solve an intertemporal problem, which is to maximise the expected discounted utility from consumption:

$$E \sum_{s=t}^{\infty} \beta^{s-t} u(c_s), \quad \text{with} \quad u(c_s) = \frac{c_s^{1-\phi} - 1}{1 - \phi},$$

where $\phi$ is a parameter governing the constant degree of relative risk-aversion, and $\beta \in (0, 1)$ is the discount factor. Both parameters are common across agents.

Entrepreneurs - Agents who decide to operate as entrepreneurs rent capital, $k$, and labor, $l$, to produce a homogeneous output good using a production function with decreasing returns to scale $f(e, k, l) = e(k^{1-\alpha}l^{1-\alpha})^{\gamma}$. The assumption of a perfectly competitive financial intermediary sector implies that the cost of renting capital is equal to the sum of the returns on households deposited assets $r$ - the interest rate in the economy - and the capital depreciation rate $\delta$.

Following Buera and Shin (2013), we assume that individual-specific taxes and subsidies distort the idiosyncratic returns to production. This is a conventional and parsimonious way of introducing distortions to the competitive allocation of resources by positing idiosyncratic wedges. Namely, we assume that the returns to an individual entrepreneur of producing $f$ units of the output good is $(1 - \tau)f$, where $\tau$ is a random variable with two possible outcomes: a tax rate $\tau^+ > 0$, and a subsidy rate $\tau^- < 0$. The persistence of individual distortions is tied to the persistence of entrepreneurial ability. In fact, entrepreneurs who, at the beginning of a period, retain their ability $e$ with probability $\psi$, also retain their idiosyncratic distortion $\tau$. Whenever instead agents draw a new ability $e$, they also draw a new $\tau$. The persistence parameter $\psi$ is calibrated in Section 5.1 to match the establishment turnover rate in the UK. We therefore think of a new draw of a $(e, \tau)$ pair as the death of an obsolete establishment, which is immediately replaced by a new business.
In addition, and again following Buera and Shin (2013), we assume that the probability of being taxed is increasing in the level of ability: indeed, the probability that a type $e$ worker is taxed, $Pr\{\tau = \tau^+|e\}$, is equal to $1 - exp\{-ge\}$. In order to focus on the effects of misallocation, we assume that the government balances the budget, and hence in every period the amount of taxes levied on a subset of the entrepreneurs is redistributed to the rest of the firms as a subsidy. In this case taxes and subsidies do not produce a direct effect on aggregate productivity, but only an indirect effect through resource misallocation\(^\text{16}\).

We define a state-contingent policy to be a specific pair of values for $\{\tau^+, \tau^-\}$ associated with a particular policy state $\zeta$. For instance, at the time when the outcome of the referendum is announced, the economy is assumed to be in a pre-Brexit policy state, denoted by $\zeta^A$, which maps into a given pair of realizations for $\tau^+$ and $\tau^-$, denoted as $\tau^+_A$ and $\tau^-_A$. The future policy state of the economy, which is realized after Brexit takes place, can be in either of two states: an optimistic $\zeta^S$ state, in the case of "soft Brexit", characterized by a relatively low level of distortions, and a pessimistic state $\zeta^H$, in the case of "hard Brexit", characterized by a higher level of distortions. These two post-Brexit states map into a different pair of values for $\tau^+$ and $\tau^-$ denoted by $\tau^+_j$ and $\tau^-_j$, for $j = \{S, H\}$.

The problem of the entrepreneur is to choose labor and capital in order to maximize profits:

$$\pi(e_s, a_s, \tau_s; \zeta_s) = \max_{l_s, k_s} \{1 - \tau(\zeta_s)\} f(e_s, k_s, l_s) - w l_s - (r_s + \delta)k_s\}$$

subject to

$$k_s \leq \lambda a_s,$$

where the parameter $\lambda \in (1, \infty)$ captures a financial friction, which applies equally to all individual workers, and implies that any entrepreneur is only able to borrow up to a fraction $\lambda$ of his wealth. This is a parsimonious way of modelling financial frictions, and can be thought of as deriving from a standard limited-enforcement problem. If if $\lambda = 1$, the economy is under financial autarky and entrepreneurs are self-financed, whereas if $\lambda = \infty$ capital markets are perfects.

In equilibrium, the financial constraint does not bind for the individuals who choose to become entrepreneurs; it only binds for the individual who choose to be workers. Hence, the role of the financial friction in this model is to prevent talented but poor individual from efficiently operating a business.

**Occupational choice** - Every period, the agents solve the following static maximization problem for their occupational choice:

$$\max \{w_s, \pi(e_s, a_s, \tau_s; \zeta_s)\}.$$  \hspace{1cm} (4)

The policy function implied by this problem is such that an agent will optimally decide to operate as an entrepreneur only so long as he can operate the business on a sufficiently large scale. That is, if he is wealthy enough to overcome the financial constraint. Because the profit function is increasing in the level of entrepreneurial ability, the threshold level of wealth required to operate as entrepreneurs will depend on the level of ability $a(e)$. This threshold value is defined as the level of wealth such that an agent is indifferent between being an entrepreneur or a laborer:

$$\pi(e_s, a_s(e_s), \tau_s; \zeta_s) = w_s.$$ \hspace{1cm} (5)

In the limit case where capital markets are perfect and therefore entrepreneurs do not face borrowing constraints, the occupational choice only depends on ability.

\(^{16}\)Specifically, let $I$ be the total set of firms such that $i \in I$. Let $I^+$ be the set of taxed firms and let $I^-$ the set of subsidized firms, the balanced budget can be written as $\tau^+ \int_{i \in I^+} f(e_{is}, k_{is}, l_{is}) \ di = -\tau^- \int_{i \in I^-} f(e_{is}, k_{is}, l_{is}) \ di$. 


**Aggregate uncertainty** - We model the referendum as an unanticipated news that a new policy will be implemented in the future. This announcement entails uncertainty about both the future policy state, soft or hard Brexit, and the timing of Brexit. Specifically, we assume that in each period of time there is a given probability \( \theta \) that Brexit takes place. Conditional on Brexit, the economy moves into either the soft Brexit state \( \zeta^S \) with probability \( \gamma \), or into the hard-Brexit state \( \zeta^H \) with the complement probability \( 1 - \gamma \). These are absorbing Markov states, meaning that once the new policy is implemented it cannot be reverted and the economy will stay in that state forever. With probability \( 1 - \theta \) instead, the economy remains in the announcement state \( \zeta^A \). The transition probabilities for the stochastic policy state can be described by the following transition matrix:

\[
P(\zeta_{s+1} = \zeta^m_{s+1} | \zeta_s = \zeta^j_s) = \begin{pmatrix}
\zeta^A_{s+1} & \zeta^S_{s+1} & \zeta^H_{s+1} \\
1 - \theta & \theta \gamma & \theta (1 - \gamma) \\
0 & 1 & 0
\end{pmatrix}.
\]

(6)

We assume that at the time of the referendum the economy is in the initial steady-state that corresponds to the policy state \( \zeta^A \). Specifically, we assume that \( \theta = 0 \), meaning that agents expect to remain in this policy-state forever. Hence, we regard \( \theta \) as a state, which changes from zero to a strictly positive value at the time of the referendum. This unanticipated shock to the Poisson probability that a new policy is implemented, \( \theta \), results in a stochastic transition from the initial pre-Brexit steady-state to a terminal post-Brexit steady state.

**The individual’s intertemporal problem** - The recursive formulation of the agents’ intertemporal problem is to maximize the value function:

\[
V(e_s, a_s, \tau_s; \zeta_s, \theta_s, \Gamma_s) = \max_{c_s, a_{s+1}} u(c_s) + \beta E_t \{ V(e_{s+1}, a_{s+1}, \tau_{s+1}; \zeta_{s+1}, \theta_{s+1}, \Gamma_{s+1}) | e_s, \zeta_s, \theta_s \},
\]

subject to the no-borrowing constraint

\[ a_{s+1} \geq 0, \]

the budget constraint

\[ c_s + a_{s+1} \leq \max \{ w_s, \pi(e_s, a_s, \tau_s; \zeta_s) \} + (1 + r_s) a_s, \]

with

\[
\pi(e_s, a_s, \tau_s; \zeta_s) = \max_{l_s, k_s \leq \lambda} \{ (1 - \tau_s) f(e_s, k_s, l_s) - w_s l_s - (r_s + \delta) k_s \},
\]

subject to the law of motion \( H \) for the joint distribution over assets and ability \( \Gamma_s, \)

\[ \Gamma_{s+1} = H(\Gamma_s, \zeta_s, \zeta_{s+1}), \]

and taking as given the exogenous processes for \( e, \zeta \) and \( \theta \) as well as the state contingent policies \( \tau(\zeta_s) \). The introduction of policy uncertainty through the state variable \( \zeta_s \) generates aggregate state uncertainty since changes in the policy affect aggregate productivity and prices. In this case agents need to forecast the next period joint distribution \( \Gamma_{s+1} \) in order to predict future prices. The law of motion \( H \) for the endogenous distribution depends endogenously on \( \Gamma_s \) and on the transition matrix for the exogenous stochastic state variable \( \zeta_s \).
It is possible to rewrite the individual problem by opening the expectation over the future policy state using the probabilities in the transition matrix (3.1):

\[
V(e_{is}, a_{is}, \tau_{is}, \zeta_{is}, \theta_{is}, \Gamma_{is}) = \max_{c_{is}, a_{is+1} \geq 0} u(c_{is}) + \beta \{ \mathbb{P}(\zeta_{s+1}^A | \xi_s) E_t V(e_{is+1}, a_{is+1}, \tau_{is}, \zeta_{is+1}^A, \theta_{is+1}, \Gamma_{is+1}) \\
+ \mathbb{P}(\zeta_{s+1}^S | \xi_s) E_t V(e_{is+1}, a_{is+1}, \tau_{is}, \zeta_{is+1}^S, \theta_{is+1}, \Gamma_{is+1}) \\
+ \mathbb{P}(\zeta_{s+1}^H | \xi_s) E_t V(e_{is+1}, a_{is+1}, \tau_{is}, \zeta_{is+1}^H, \theta_{is+1}, \Gamma_{is+1}) \}.
\]

(9)

Recursive Competitive Equilibrium— Denote \( F : a_{s+1} = F(a_{is}, e_{is}, \tau_{is}; \Gamma_{is}, \zeta_{is}) \) as the optimal decision rule for asset holdings. A recursive competitive equilibrium is then a pair of individual functions \( V \) and \( F \), a pair of price functions \( (r, w) \) and a law of motion \( H \), such that: \( V \) and \( F \) solve the individual’s problem in (9), (ii) \( r \) and \( w \) are competitive (capital and labor demand solve (8) and both markets clear), and (iii) \( H \) is generated by \( F \), that is, the appropriate summing up of agents’ optimal choices of capital, given their current status in terms of wealth and ability.

4 The experiment

To quantify the effects of Brexit we will calibrate the model of the previous Section, and compute transitional dynamics from an initial pre-Brexit steady state to the time when the Brexit policy is implemented, and then all the way towards either the Soft or the Hard Brexit steady-states. In order to compute the effects of policy uncertainty we will then compare these dynamics against a counter-factual where policy uncertainty is shut down. This exercise will allow us to compute the effects of uncertainty on the behavior of key macroeconomic variables as well as the fraction of wages that agents of different ability and wealth would be willing to give up at the time of the referendum in order avoid uncertainty.

Technically, policy uncertainty is removed by substituting the stochastic transition matrix in (3.1) with a deterministic process that triggers hard or soft Brexit after a predetermined number of periods. In this counterfactual scenario agents know since the referendum the precise time when Brexit will takes place, and whether it will be a hard or soft Brexit. We will also be able to separate the effects of timing uncertainty vs. uncertainty on the size of the distortions by assuming that the Soft and Hard Brexit outcomes entail the same level of wedges, thereby retaining only timing uncertainty. The solution methods used to compute the transitional dynamics with and without policy uncertainty are relegated to Appendix A.

5 Calibration

The initial steady-state of the model is calibrated to reflect the UK economy over the years 1992-2015, under the assumption that one period of time in the model corresponds to one year. This stationary equilibrium is meant to represent the UK economy prior to the referendum of June 2016.

5.1 Calibration of the initial (pre-referendum) steady state

Before we can assign numerical values to the parameters of the model, we need to specify the functional form for the distribution of entrepreneurial ability \( e \). We follow Buera and Shin (2013) and assume a truncated and discretized version of a Pareto distribution whose probability density is \( \eta e^{-(\eta+1)} \) for \( e \geq 1 \). Hence, the parameter \( \eta \) governs the dispersion of \( e \) across
the population of workers. The persistence of the individual values of \( e \) over time is instead controlled by the parameter \( \psi \), which measures the probability that a worker retains his ability. The calibration exercise requires assigning numerical values to 11 parameters, which are reported in Table 1 below. Some parameters are set using a-priori information; the remaining ones are set in order to target key moments of the UK economy over the period 1992-2015. With regards to the first set of parameters, the output elasticity to capital \( \alpha \) is set to 0.381 to match the average labour share of income based on data from the Office of National Statistics (ONS).\(^{17}\)

The annual depreciation rate \( \delta \) is set to 8%, which corresponds to the ratio of capital consumption over total fixed capital reported by the ONS.\(^{18}\) Finally, the coefficient of risk aversion is equal to 1.5, the same value used by Buera and Shin (2013), which is common in the literature.

This leaves us with eight parameters and eight respective moments conditions to satisfy. Although these moments are all determined simultaneously, some parameters are particularly informative in targeting a specific moment. In this sense, we set \((i)\) the discount factor \( \beta \) to match an average UK real interest rate of 1.81%;\(^{19}\) \((ii)\) the collateral constraint parameter \( \lambda \) is set so to achieve a credit to GDP ratio of 134.9%, as reported by the ONS; \((iii)\) the auto-regressive coefficient for ability \( \psi \) is calibrated to match a 9% firm exit rate, based on ONS computations;\(^{20}\) \((iv)\) the span of control parameter \( \nu \) and \((v)\) the ability distribution parameter \( \eta \) are calibrated to match a 81.3% employment share for the 18% largest firm, as reported by the the Department for Business Innovation and Skills, and an earning share of 25.2% for the top 10% earners, as reported by the ONS.\(^{21}\)

### 5.2 Parameterization of policy parameters

We turn to the giving values to the policy parameters. Since the exact impact of a ‘Soft’ or a ‘Hard’ Brexit on resource misallocation are hard to quantify, we will explore the parameter space of the policy parameter \( \tau \) in order to evaluate the effects pf policy uncertainty. The only restriction we place is that a ‘Hard’ Brexit introduces higher idiosyncratic distortions than a ‘Soft’ Brexit.

For the moment being we will concentrate on the scenario whereby any type of Brexit will bring about more distortions and resource misallocation. In later versions of the paper we will analyze different scenarios for the Hard and Soft Brexit policy parameters to ensue the result are robust to different parameters. Hence, we assume that in the announcement state the economy does not suffer any distortions hence the tax rate is zero \( \tau_A^+ = 0 \). We then hypothesize that a Soft Brexit implies a tax rate of \( \tau_A^S = 2\% \) and a Hard Brexit a tax rate of \( \tau_H^+ = 5\% \). The subsidy rate for the respective states are set such to ensure that the government budget is balanced. The parameter governing the dispersion of the probability distribution of being taxed is set to \( q = 1.55 \) as in Buera and Shin (2013).

Under the policy announcement with perfect information we set the lag of years between the announcement and the implementation of the policy, \( n \), to six years. This value represents the average duration of the Brexit negotiations between the optimistic scenario, which sees the UK formally leaving the EU in three years following the referendum, and the pessimistic scenario, where it takes 10 years for the parties to resolve the issue. By contrast, under the

---

17 ONS - Labour share (\%) of GDP
18 ONS - Capital stocks, consumption of fixed capital
19 The real interest rate is calculated as the yearly nominal interest rate minus the GDP deflator
20 Business Demography 2015 Dataset from the Office for National Statistics
21 The UK firm employment share is obtained from the BUSINESS POPULATION ESTIMATES FOR THE UK AND REGIONS 2015 - Department of Business, Innovation & Skills (BIS) The UK’s earning share is gathered from The effects of taxes and benefits on household income in 2015 Dataset from the Office for National Statistics
policy announcement with policy uncertainty we set the per-period probability of the policy implementation (the UK leaving the EU) such that agents can expect the lag to last six years, the same as in the perfect information case. Moreover, we postulate that given the UK’s exit from the EU there is an equal probability of a Soft or a Hard Brexit.

6 Results

In this section we first analyze the steady state results of the model in which we will compare the steady states of the three different policy states to evaluate the effects of the different Brexit scenarios; and secondly we investigate the transitional dynamics from the starting steady state where Brexit is not announced to the Soft and Hard Brexit steady states.

6.1 Steady State Analysis

Having calibrated the model to the pre-referendum economy as in the previous section, we move to compare the starting steady state to the Soft and Hard Brexit steady state where the respective tax and subsidy policy have been implemented. Such experiment is useful to gain an insight on the effect of Brexit on the economy in the long-run through the resource misallocation channel.

Figure 6 displays the values of the macroeconomic variables of interest in the three different steady states. The introduction of the policies induces an inefficient allocation of resources in the economy both in the Soft and Hard Brexit case. The misallocation of resource occurs on two fronts: the intensive margin and the extensive margin. In the intensive margin, the factors of production (capital and labour) are reallocated from productive entrepreneurs to the now-subsidized less productive entrepreneurs. Whilst in the extensive margin the now-taxed productive entrepreneurs will exit the production process replaced by the no-subsidized less productive entrepreneurs. Such inefficient allocation of resources produces a drop in total factor productivity of 6% in the case of Soft Brexit and of 8% in the case of Hard Brexit. The lower aggregate productivity is accompanied by lower capital and labour as the less-productive entrepreneurs will have a lower demand for the factors of production than the productive entrepreneurs they replaced, which lower both the wage and interest rate. Overall, there is a collapse in output of 4% in the case of Soft Brexit and of 7% in the case of Hard Brexit. Given that the GDP in the UK was £477 bn in the start of 2016, should the UK negotiate and implement a Soft Brexit the result would be a loss of £22 bn, where as the loss would amount to £35 bn in the event of Hard Brexit.

6.2 Transitional Dynamics

So to understand the effects of uncertainty created by the announcement of the result of the EU referendum we turn to investigating the transitional dynamics of a simulation whereby the economy commences in the pre-referendum economy, in period \( t = 1 \) the agents are informed about the future implementation of Brexit at time \( t = N \). In order to isolate the effect of uncertainty in the economy in time period after the announcement of Brexit and before its implementation, we compare the simulation of such economy under two different scenarios. In the first scenario, the imperfect information case, the agents are not aware about the exact date of the implementation of Brexit and will not know the exact size of the policy’s tax and subsidies. In the counter-factual scenario, the perfect information case, we simulate the counter-factual economy under a perfect information scenario where the agents at time \( t = 1 \) will know exactly when Brexit will be implemented and the size of taxes and subsidy they will face once
the policy is implemented. The perfect information counter-factual is solved using backwards looking methods, whilst the imperfect information simulation is solved using forward looking methods.

Figures 1 and 2 illustrate the transitional dynamics to a Soft Brexit and a Hard Brexit steady state respectively. It is evident from the figures that the announcement of Brexit and the uncertainty it brings does not matter much for the aggregate dynamics of the macro variables even though the long-run effects of the polices are great. In our framework, the effect of uncertainty does not produce the sharp drop in macroeconomic variables which standard models of uncertainty à la Bloom (2009) are able to produce. Indeed from the announce periods to the implementation of Brexit, uncertainty only generates a smaller exit from from production to labor which does not imply much for the aggregate economy aside from a smaller increase in investment cause by slower capital accumulation. However, on the whole aggregate uncertainty doe not have any effect output or TFP.

In the period Brexit is implemented, TFP suffers a drop of 1.5% on impact in the Soft Brexit Scenario, and of 4% in the Hard Brexit case. Such TFP dynamic is given by the intensive margin and the extensive margin of the occupation decision agents face. The sudden increase in productive agents that are now likely to be taxed and thus either scale back production to inefficient levels (intensive margin) or exit production completely and move into being laborers (extensive margin). By the same logic, the is an entry of now-subsidized unproductive agents which increase the scale of operation beyond their efficient levels (intensive margin) or become newly-entrepreneurs (extensive margin).

Given the dynamics of the agent’s occupational decisions, the wage and interest rate decrease due as there is less demand for the factors of production thus slowing down investment leading a decumulation of capital. Output fall by 1.5% and 3.75% in the Soft and Hard Brexit scenarios respectively due to the fall in aggregate productivity, as well as the scaling back of production by productive entrepreneurs not compensated by the now-subsidized unproductive entrepreneurs. Lower earnings, given by the drop in profits and in the wage, lead a drop in consumption.

Following the implementation of Brexit the economy transition to its new steady state. (TO BE COMPLETED)

6.3 Heterogeneous Effects of Policy Uncertainty

Even though policy uncertainty does not have great implications in the aggregate, the framework we have developed allows us to analyze the effects of policy uncertainty on different types of agents and theirs decision rules. (TO BE COMPLETED)

7 Conclusion

One of the most salient political event currently unfolding in advanced economies is indeed the drift towards populism. And a distinctive feature of populist movements is an agenda of protectionist policies aimed at shielding businesses and jobs in declining industries from the forces of international competition. Namely, populism advocates for a package of large-scale reforms that encompass restrictions in targeted migration inflows, limitations to competition and a retreat from free trade arrangements, among a whole host of measures aimed at distorting market behavior. All such policies generate distortions to the prices faced by individual

\[22\] For more information about the solution methods regarding the transitional dynamics please see Appendix A.
producers, leading to reallocation of resources across establishments, with potentially important consequence for productivity in the long run (see Restuccia and Rogerson (2008) and Buera and Shin (2013)). The effects of uncertainty over such policies can be naturally studied within our proposed framework, and we leave this for future work.
References


Appendix A  Computational Strategy

In this section we describe how the model’s steady state is obtained and how the transitional dynamics are computed.

First we describe how we discretized the state space:

- The ability grid \((e)\) consists of 5 linearly spaced points between 1 and 6. Their probability is distributed along a Pareto distribution governed by the dispersion parameter \(\eta\). Since the taxes and subsidies are formulated to be equivalent to a monotonic transformation of the ability level, we can transform the ability grid for all policy states as such: \((1 - \tau^j)e_i\) for all \(\zeta^j\) where \(j \in \{A, S, H\}\). Ergo, the transformed ability grid is made up of 10 points.

- The asset grid \((a)\) is made up of 10 non-equidistant points between 0 and \(1e^5\).

- The aggregate capital grid \((K)\) is made up of 5 linearly spaced points between 2 and 10.

- There is a total of 3 aggregate states: the announcement state, the Soft Brexit state, and the Hard Brexit state.

- Overall, the state space for computational purposes is \(10 \times 10 \times 5 \times 3\).

A.1 Steady states

The steady states can be solved by bisecting the aggregate prices in the economy such that both the capital and the labor markets clear. The algorithm goes as follows:

1 - Start by guessing an upper and lower bounds for both prices, that is, the interest rate \(r\) and the wage \(w\). Check that for the lower bound (upper) bound of each price the competitive equilibrium yields and excess demand (supply).

2 - Given the the initial lower and upper bounds, bisect the the interest rate and wage \((r^*, w^*)\). Then, solve the model for the competitive equilibrium using the bisected prices and obtain the stationary distribution and aggregate quantities.

3 - Check whether the labor market clears. If the labor market exhibits excess demand (supply) the replace the lower (upper) bound of the wage with \(w^*\) and repeat Step 2 until the labor market clears.

3 - Once the labor market has cleared, check whether the capital market clears. If the capital market exhibits excess demand (supply) the replace the lower (upper) bound of the interest rate with \(r^*\) and repeat Step 2 and 3 until the capital market clears.

A.2 Transitional dynamics

We can turn to the transitional dynamics. In the endeavor of unraveling the short-term effects of uncertainty generated by the policy from the long-run effect of the actual policy, we must: (i) compute the transitional dynamics under prefect information, that is, in a setting where agents know when the timing and size of the policy; (ii) and then, compute the transitional dynamics under imperfect information, where agents don’t know when the policy is going to be implemented, nor its size.

Backward induction algorithm - The transitional dynamics under perfect information are computed by backward induction. In this setting, there is no uncertainty surrounding the

\[23\text{The goods market will clear thanks to Walras’ law.}\]
policy state, therefore the agents do not need to track the joint distribution \( \Gamma_{s+1} \). Indeed, in this counterfactual the stochastic aggregate transition matrix is replaced with a deterministic one. That is, since we are obtaining the transitional dynamics for an anticipated policy, for the first \( N - 1 \) periods (where \( N \) is the period when the policy is implement) we will solve model imposing the announcement state \( \zeta^A \), whilst for \( t = N, ... T \) (where \( T \) is the terminal period) we will solve the model using the policy states \( \hat{\zeta}^i \). We fix \( T = 15 \) and \( N = 6 \). For the transition from \( \zeta^A \) to \( \zeta^j \) where \( j \in \{S, H\} \):

1. Guess an interest rate sequence \( \{r_t\}_{t=0}^T \).
2. Guess a wage sequence \( \{w_t\}_{t=0}^T \).
3. Compute the value function of the terminal stationary equilibrium with state \( \zeta^j \), and let \( v_T(a, e) = v(a, e) \). Moreover, compute the initial stationary distribution \( G_0(a, e) \) by solving for the steady state in state \( \zeta^A \). By backward induction, taking the wage sequence and the interest rate sequences as given, compute the value function \( v_t(a, e) \) for \( t = T - 1, ..., N \) and the optimal decision rules \( f(a_t, e_t) \) for \( t = T - 1, ..., N \). Using the initial stationary distribution \( G(a_0, e_0) \), the optimal policy rules, and the ability transition matrix \( Y(e_t, e_{t+1}) \), update the distribution \( G(a_{t+1}, e_{t+1}) \) for every \( t = 1, ..., T \) and obtain the aggregate quantities.
4. Check whether the labor market clears in every period. If not, update the wage sequence accordingly, where \( \eta^w \) is the wage updating parameter, and \( \chi^l_t \) is the excess labor demand for every \( t = T - 1, ..., 0 : w_t = w_t + \eta^w \chi^l_t \). Repeat Step 3 until the labor market clears in all periods.
4. Once the wage sequence converges, check whether the capital market clears in all periods.
   If not, update the interest rate sequence accordingly, where \( \eta^r \) is the interest rate updating parameter, and \( \chi^k_t \) is the excess capital demand for every \( t = T - 1, ..., 0 : r_t = r_t + \eta^r \chi^k_t \). Repeat Steps 2-4 until the the capital market clears in all periods.

As we cannot guarantee the uniqueness of a numerically-constructed competitive equilibrium, we tried many different initial guesses of the wage and interest rate sequences, as well as several values of the relaxation parameters \((\eta^r, \eta^w)\). All our competitive equilibria withstood these robustness checks.

**Krusell and Smith (1998) algorithm** - The transitional dynamics under imperfect information require the use of the Krusell and Smith (1998) algorithm. In this setting, the agents face aggregate uncertainty and thus need to forecast the joint distribution \( \Gamma_{s+1} \) as well as tomorrow’s prices \((r_{s+1}, w_{s+1})\) for all three states. With respect the joint distribution \( \Gamma_{s+1} \) it is sufficient to track just the first moment \( m_{s+1} \) as demonstrated by Krusell and Smith (1998).

As a result of the introduction of aggregate uncertainty, we require agents to formulate laws of motion for the first moment of the joint distribution and so must choose the appropriate functional forms for such beliefs:

\[
\log(m_{s+1}) = \beta^m_0 + \beta^m_1 \log(m_s) \quad \forall \; \zeta \in \{\zeta^A, \zeta^S, \zeta^H\},
\]

for the future interest rate:

\[
r_{s+1} = \beta^r_0 + \beta^r_1 \log(m_s) \quad \forall \; \zeta \in \{\zeta^A, \zeta^S, \zeta^H\},
\]

and finally for the future wage rate:

\[
\log(w_{s+1}) = \beta^w_0 + \beta^w_1 \log(m_s) \quad \forall \; \zeta \in \{\zeta^A, \zeta^S, \zeta^H\}.
\]

\(24\) We also use 200 and 250 and the results do not change.
Once specified the functional forms of the agent’s beliefs, we turn to algorithm for solving the transitional dynamics under aggregate uncertainty:

1- Guess the coefficients for the laws of motions: $\beta^i_j \zeta^l$, where $j \in \{1, 0\}$, $i \in \{m, r, w\}$, and $\zeta \in \{\zeta^A, \zeta^S, \zeta^H\}$.

2- Obtain the forecast for the first moment of the joint distribution $m_{t+1}(\zeta, K)$, the interest rate $r_{t+1}(\zeta, K)$, and wage $w_{t+1}(\zeta, K)$ for all grid points in the aggregate capital grid $K$ and for all policy states.

3- Obtain the value function for the consumer’s problem $v(a, e; \zeta, K)$ for the state space by value function iteration.

4- Simulate the economy. Generate a time series of aggregate shocks $\zeta^l$ where $j \in \{S, H\}$ for $t = 1, ..., T$ for each policy state. For each of the policy states $\zeta^l$ where $j \in \{S, H\}$ and for every period $t = 1, ..., T$, where $T = 15$:

   i- Obtain the level of capital in this period $m_t$ and forecast the next period of capital $m_{t+1}$.

   ii- Start by guessing an upper and lower bounds for both prices, that is, the interest rate $r_t$ and the wage $w_t$. Check that for the lower bound (upper) bound of each price the competitive equilibrium yields and excess demand (supply).

   iii - Given the the initial lower and upper bounds, bisect the the interest rate and wage $(r^*_t, w^*_t)$. Then, obtain next period’s value function $v(a, e; \zeta, m_{t+1})$ by interpolating the value function $v(a, e; \zeta, K)$ on the aggregate capital grid. Get this period’s value function $v(a, e; \zeta, m_t)$ and optimal decision rules by solving the agents’ problem. Update the distribution $G(a_{t+1}, e_{t+1})$ and obtain the aggregate quantities.

   iv- Check whether the labor market clears. If the labor market exhibits excess demand (supply) the replace the lower (upper) bound of the wage with $w^*$ and repeat Step (ii) until the labor market clears.

   v - Once the labor market has cleared, check whether the capital market clears. If the capital market exhibits excess demand (supply) the replace the lower (upper) bound of the interest rate with $r^*$ and repeat Steps (ii) and (iii) until the capital market clears.

5- Once we have obtained the two time-series, regress the independent variable $\{m_t\}_{t=0}^{T-1}$ on the depend variables $\{m_{t+1}\}_{t=0}^{T-1}, \{r_t\}_{t=0}^{T-1}$ and $\{w_t\}_{t=0}^{T-1}$ and obtain the coefficients $\beta^i_j \zeta^l$.

6- Check whether the coefficients of the laws of motion converge. If not, use the coefficients of the regressions $\beta^i_j \zeta^l$, to update the coefficients of the laws of motion using the relation parameter $\phi_j$ accordingly: $\beta^i_j \zeta^l = \beta^i_j \zeta^l \phi + (1 - \phi_j) \beta^i_j \zeta^l$, and repeat Steps (2-5).

---

25 We also use 200 and 250 and the results do not change.
## Appendix B  Tables & Figures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.381</td>
<td>Labor output share</td>
<td>Office for National Statistics</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.080</td>
<td>Annual depreciation rate</td>
<td>Office for National Statistics</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.922</td>
<td>Real interest rate</td>
<td>World Bank</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>2.750</td>
<td>Credit to GDP ratio</td>
<td>World Bank</td>
</tr>
<tr>
<td>$\psi$</td>
<td>0.900</td>
<td>Firm exit rate</td>
<td>Office for National Statistics</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.210</td>
<td>Top 5% firm employment share</td>
<td>BIS, Business Population Estimates</td>
</tr>
<tr>
<td>$\eta$</td>
<td>5.600</td>
<td>Top 10% earning share</td>
<td>Office for National Statistics</td>
</tr>
<tr>
<td>$\tau^+$</td>
<td>0.125</td>
<td>U.K.’s TFP relative to U.S.</td>
<td>World Bank</td>
</tr>
<tr>
<td>$\tau^-$</td>
<td>0.268</td>
<td>Government balance budget</td>
<td></td>
</tr>
<tr>
<td>$q$</td>
<td>1.554</td>
<td>U.K.’s capital to output ratio</td>
<td>World Bank</td>
</tr>
</tbody>
</table>

Table 1: Baseline Model Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n$</td>
<td>6</td>
<td>Policy implementation lag</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>$1/6$</td>
<td>Probability of policy implementation</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.500</td>
<td>Probability of ‘Soft’ Brexit</td>
</tr>
</tbody>
</table>

Table 2: Policy Parameters

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Pre-Referendum</th>
<th>Soft Brexit</th>
<th>Hard Brexit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilibrium Interest Rate</td>
<td>0.01849</td>
<td>0.01539</td>
<td>0.01501</td>
</tr>
<tr>
<td>Equilibrium Wage</td>
<td>0.71016</td>
<td>0.69808</td>
<td>0.64447</td>
</tr>
<tr>
<td>Capital</td>
<td>1.39752</td>
<td>1.45599</td>
<td>1.45427</td>
</tr>
<tr>
<td>Labour</td>
<td>0.92434</td>
<td>0.90594</td>
<td>0.85985</td>
</tr>
<tr>
<td>GDP</td>
<td>0.85373</td>
<td>0.81263</td>
<td>0.79066</td>
</tr>
<tr>
<td>TFP</td>
<td>0.75152</td>
<td>0.70426</td>
<td>0.68552</td>
</tr>
<tr>
<td>Investment</td>
<td>0.31153</td>
<td>0.25153</td>
<td>0.23985</td>
</tr>
<tr>
<td>Credit to GDP</td>
<td>1.35668</td>
<td>1.12119</td>
<td>1.10088</td>
</tr>
</tbody>
</table>

Table 3: Competitive Equilibrium
### Percentage Welfare Losses

<table>
<thead>
<tr>
<th></th>
<th>Soft Brexit</th>
<th>Hard Brexit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labourer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: My caption

### Percentage Investment Change

<table>
<thead>
<tr>
<th></th>
<th>Soft Brexit</th>
<th>Hard Brexit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: My caption
Figure 1: Transitional Dynamics to Soft-Brexit State
Figure 2: Transitional Dynamics to Hard-Brexit State