Talk is not cheap: Policy agendas, information processing, and the unusually proportional nature of ECB communications policy responses.

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Abstract

This study unveils the policy agenda of the ECB Governing Council as found in the speeches that Governing Council Members gave between 1999 and 2018. Using a dynamic topic-modelling approached based on non-negative matrix factorisation, we demonstrate how the issues discussed by ECB Governing Council members have evolved over time, and how the general punctuation hypothesis (Jones & Baumgartner 2005) sheds light on what drives this process. We find that unlike policy outputs from many other policy-making systems, ECB communications evolve in a proportional manner. We attribute this finding to the information-processing capacities of the bank. Our findings speak to the literatures on Central Bank communications, the evolution of policy agendas, and the application of topic models to speech texts.

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1 Introduction

Since the creation of the Euro, the European Central Bank (ECB) has established itself as a core European institution, whose policy choices and actions have a fundamental effect on the European and indeed world economy. It has been mandated with wide-ranging powers as the sole institution tasked with defining and implementing monetary policy for Euro-area members, and since the crisis, it has also gained an increasing role in banking supervision and macro-prudential policy. Despite the ECB's wide-ranging policy-making powers, we have little systematic insight into the ECB's priorities as a policy-making institution, how these priorities have evolved over time, and what explains this evolution. We also know relatively little about how central banks compare to other policy-making systems in terms of how they process the myriad informational inputs they receive and must digest when making policy choices. Given the broad policy remit of the modern central bank, direct comparison with other policy-making systems has the potential to provide new insight into how they process information and what drives policy-agenda dynamics at the system level.

To gain insight into these issues, this study takes a policy-agenda based approach (Baumgartner and Jones, 1993; Davis et al., 1974; Jones and Baumgartner, 2005; Lindblom, 1959). We define the ECB policy agenda as the set of policy issues addressed by the ECB at a given point in time, and we aim to unveil how issue attention evolves over time. To explain the policy-agenda variation observed, we appeal to information-processing theory, and the general punctuation hypothesis that has emerged in this literature. This hypothesis holds that the ability of a policy-makers to respond to the policy signals they receive in a proportional

manner is determined by the level of friction present in the policy-making system. Most policy-making systems that have been studied to date are characterised by relatively high levels of friction, which leads to disproportionate information processing, and the emergence of punctuated equilibrium dynamics. We argue that central banks are different because they have improved information-processing mechanisms built into their institutional structure, which aid the efficient processing of policy signals and proportional responses to the policy challenges they face.

Our main contention is that central banks are *explicitly designed* to address the cognitive and institutional frictions that in other policy-making environments generate policy-agenda punctuations. In most cases, central banks are mandated to pursue price stability and to address developing economic risks before such risks become acute and require major policy change (Blinder et al., 2008). If we find that policy-agenda dynamics in central banks respond to the policy challenges faced in a proportional manner, then we have identified a policy-making context in which punctuated equilibrium dynamics are minimised. Studying central bank policy agendas can thus help provide new insight into the scope conditions under which the general punctuation hypothesis holds.

To empirically assess the explanatory power of information-processing theory, we examine the policy content of the speeches made by the ECB Governing Council. We argue that such speeches are a strong indicator of where ECB policy attention rests at a given point in time. Speeches describe policy actions taken, attempt to legitimise these actions, and have become an important policy tool used to shape market expectations and behaviour. Alongside accounting for the current policy stance, speeches also provide forward guidance on future policy direction, based on the ECB's current analysis of the economic situation and pro-

jections about future market developments (Holmes, 2013). They are carefully written with credibility in mind, and heavily based upon the research activities of the bank. As a result, speeches can be thought of as one of the key policy outputs of the ECB.

The argument that speeches are now considered a policy tool in and of themselves is perfectly illustrated by the effects of a famous speech made at the height of the Eurocrisis by the ECB Governor, Mario Draghi, on 26 July 2012. In this speech, Draghi stated that "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough." The substantive impact of this calculated policy statement was immediate, with market sentiment significantly improving as expectations that the ECB was fully committed to resolving the crisis solidified. A week later, the ECB announced the introduction of a concrete policy tool to achieve this goal (Outright Monetary Transactions), but this policy tool *was never used*. The statement of intent was enough to shape market participants' future expectations about the viability of the Euro and their resulting behaviour (De Grauwe and Ji, 2013; Saka et al., 2015). We can thus conclude that as a policy tool for managing market expectations, speeches are very effective.

To analyse and explore the latent policy content of the large corpus of ECB speeches under consideration in this study, we use a dynamic topic model based on two layers of non-negative matrix factorisation (Lee and Seung, 1999) to capture the dynamics of the ECB policy agenda.[1] This allows us to capture 56 policy topics to which attention is paid, and track the evolution of attention to these topics over time. This method is unsupervised in nature, as the corpus does not include

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[1]A detailed description of the methods employed is provided in the online appendix.

manually-annotated labels or metadata to indicate the category or topical content of each speech. Our findings suggest that ECB policy-agenda dynamics tend to evolve in a proportional manner, in contrast to many other policy-making systems, which exhibit punctuated equilibrium dynamics. As we shall demonstrate, this is for a good set of reasons relating directly to the nature of central banks and the way in which they process and share information when making policy.

2   Related literature

In this study, we aim to provide insight into the ECB *policy agenda* as expressed in Governing Council speeches. Our focus on the policy agenda leads us to link the literatures on policy-agenda dynamics (Baumgartner and Jones, 1993; Davis et al., 1974; Jones and Baumgartner, 2005; Lindblom, 1959) and central bank communications policy (Blinder et al., 2008; Holmes, 2013). Much like any other policy-making system, the ECB makes policy decisions in an information-rich policy environment where it can be difficult to identify policy-relevant information. This makes choosing the correct course of action challenging. Such problems are compounded by the fact that market participants pay close attention to every single policy move made by the bank, as policy decisions impact on market returns and the state of the economy. Policy mis-steps are costly as a result. This highly charged policy-making environment shapes the institutional structure of the bank, the set of available policy tools, and the way in which these policy tools are used. As shall be argued, these factors are likely to shape the evolution of the ECB policy agenda.

Punctuated equilibrium theory (PET) is now the dominant theoretical frame-

work used to explain the evolution of policy agendas. It argues that policy-agenda dynamics are characterised by long periods of stability that are interrupted from time-to-time by dramatic policy-agenda realignments (Baumgartner and Jones, 1991; Jones and Baumgartner, 2005; Baumgartner and Jones, 2002). This combination of stability and sudden change is referred to as a 'stick-slip' dynamic and is the result of frictions that restrict the flow of policy-relevant information at the individual and institutional level (Jones and Baumgartner, 2005; Jennings and John, 2009).

PET is one expression of what Workman et al. (2009) refer to as the information-processing theory of policy dynamics. Information processing is understood as the "collecting, assembling, interpreting, and prioritizing [of] signals from the environment" (Jones and Baumgartner, 2005). At the individual level, the cognitive limitations of boundedly rational policy makers shape decisions in an environment with an over-supply of policy signals, and uncertainty over the salience of each signal for making optimal policy. In such an environment, *cognitive frictions* lead policy-makers to make decisions using heuristic shortcuts based on previous experience and understanding (think of economic models), and thus under-value new information that might suggest a need for a change in policy direction. The repeated use of decision heuristics over time acts as a negative feedback mechanism limiting the possible range of policy change, and leading to policy-agenda stability.

PET also considers the cumulative effects of under-reacting to salient policy information. The incomplete processing of policy information over time results in a gradual misalignment between actual and optimal policy, and this process of misalignment continues until a point is reached where a major policy correction

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is required. A trigger event such as a crisis can reveal the underlying policy mis-alignment, and can lead to a sudden re-evaluation of existing decision heuristics. The process is self-reinforcing as affected interests mobilise in an effort to ad-dress the previously ignored issue. These positive feedback mechanisms can lead to sudden realignments or punctuations of the policy agenda (Baumgartner and Jones, 1993; Jones and Baumgartner, 2005).

At the institutional level similar negative and positive feedback mechanisms are in play. Institutional frictions lead to policy-agenda stability in the short-run, but over time can generate pent-up demand for major policy revisions. Institu-tional frictions include structures that 1) limit the policy-making powers of the actors involved through strict role definition, 2) hinder the free flow of informa-tion between different policy sub-systems in a policy-making system, and 3) give precedence to status quo policies. Institutional frictions impede the full internal-isation of all policy-relevant information, and compound the misalignment prob-lems associated with bounded rationality.

The general punctuation hypothesis summarises the net effect of these micro- and macro-level mechanisms at the policy-system level (Jones and Baumgartner, 2004). It states that as the level of friction in a policy-making system increases, punctuated equilibrium dynamics are more likely to emerge. When a policy-making institution is fully efficient at processing policy-relevant information (i.e., when little or no friction is present), policy responses are necessarily proportional to the policy signal received. While such policy-making systems are theoretically possible, they are expected to be rarely observed in practice. As frictions increase, the mechanisms associated with punctuated equilibrium assert themselves, lead-ing to disproportionate information processing and the emergence of 'stick-slip'

dynamics (Jones and Baumgartner, 2004). Strong evidence exists supporting the general punctuation hypothesis across different policy contexts, suggesting that cognitive and institutional frictions abound in most real-world policy-making systems (Jones and Baumgartner, 2004, 2005; Jones et al., 2003).

One aspect of this theoretical framework that remains relatively under-explored is the degree to which cognitive and institutional frictions can be overcome through the development of information-processing capacity in policy-making systems (Robinson, 2004; Robinson et al., 2007). While cognitive frictions are immutable, their pernicious effects can be ameliorated if decision-makers are supported by information-processing mechanisms. The cost associated with institutional frictions can be addressed by liberating policy-makers from political constraints, and carefully designing information-processing mechanisms into the fabric of the policy-making institution so that policy-relevant information gets to the right decision makers who can then act upon it (Workman et al., 2009).

2.1 Information processing in central banks

Relative to other policy-making institutions, we expect that central banks in general and the ECB in particular should be better than other policy-making systems at information processing and policy updating in a manner proportional to the policy challenges faced. This expectation is derived from a combination of central bank independence, a narrowly defined policy mandate, and institutional structures specifically designed to process information and address cognitive and institutional frictions. Central bank independence reduces institutional frictions by insulating policy makers from political interference, allowing central banks to act

earlier and more decisively when policy challenges emerge (Klomp and De Haan, 2009). A relatively narrow mandate focuses policy attention on achieving price stability. While this is a complex task, one can assume that policy-makers pay a great deal of attention to achieving this mandated goal. Inattention due to bounded rationality is less likely to be an issue in this context, thus pre-empting some of the mechanisms associated with punctuated equilibrium. Finally, policy choices are based on research and expertise that process policy signals from the economy, and feed into the policy choices made. Indeed, during his time as ECB Governor, Jean-Claude Trichet explicitly drew attention to the importance of research (information processing) in the ECB policy-making process:

> *"The ECB has at times identified issues of fundamental importance for understanding the impact of monetary policy in the euro area, upon which limited information was available. As a consequence, the ECB has decided to lead and co-ordinate research efforts through Eurosystem networks, which involved the ECB and the national central banks of the euro area."*
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> - Speech by Jean-Claude Trichet, ECB President, 21/5/2007.

All of these factors are likely to favour proportional policy adjustments, at least when compared to other policy-making systems that are less concerned with developing reputations for consistent behaviour. This is especially the case for one of the newer tools used by central banks to achieve their mandated goals: communications policy.

2.2 Central bank communications policy

Before exploring the empirical implications of the general punctuation hypothesis in central banking, it is worth considering why central bankers communicate with outside actors through communications policy in the first place. Blinder et al. (2008) argue that central banks provide information to the public on matters relating to *monetary policy* (their core mandated competency) in order to 1) communicate objectives and strategy, 2) explain policy decisions, 3) provide an overview of the economic outlook, and 4) signal future policy decisions to influence market expectations. Beyond communications relating to monetary policy, central banks also communicate about financial stability objectives and macro-prudential supervision for the same set of reasons (Born et al., 2011, 2012, 2014; Masciandaro and Romelli, 2017).

Unlike in many other policy-making contexts, in the world of central banking, *talk is not cheap*. Talk is not cheap because the public, business, and government alike allocate resources prospectively, based not just on the current economic climate, but also based on their expectations about future economic developments and a central bank's likely policy reactions to such conditions. Central banks have learned to exploit communications policy in order to influence public expectations and thus economic decisions (Holmes, 2013). ECB Governing Council speeches can thus be thought of as a highly detailed distillation of the ECB policy agenda, which are explicitly and knowingly drafted to address economic challenges, provide forward guidance, and achieve policy goals.

Because talk is not cheap, speeches are intimately connected to a central bank's reputation (Moschella and Pinto, 2018). Communicating their policy goals

allows central bankers to avoid the market volatility associated with policy 'surprises'. Consistent and predictable communications help them to establish credibility as agents of stability in the eyes of market participants, so that when the ECB makes a policy intervention, it has the intended effect on future expectations (Woodford, 2005). This link between communications policy and speeches on the one hand, and credibility and reputation on the other should incentivise policy change proportional to the policy challenges being faced, as there are significant market implications for acting otherwise (Bohl et al., 2008). Returning to Draghi's "whatever it takes" statement, while it can certainly be seen as a significant statement of policy intent reinforcing the ECB's commitment to the Euro, it was *proportional* to the policy challenges faced by the ECB at the height of the Eurocrisis, and it would only have worked if the markets saw it as credible.

3 Observable implications of the general punctuation hypothesis

To assess the degree to which the ECB can minimise the impact of cognitive and institutional frictions on the policy agenda, we employ stochastic-process methods (Breunig and Jones, 2011; Jones, 2003; Jones and Baumgartner, 2005). These methods focus on the degree to which distributions of policy-agenda change are normal or leptokurtic in nature. Since policy makers take account of multiple independent sources of information from the policy-making environment (here the economy), we can assume that changes in the information received (input signals) are normally distributed (Padgett, 1980). Policy systems differ in their ability to

process these informational inputs and react accordingly when designing policy responses. This has implications for the distribution of policy response changes observed.

The distribution of policy responses associated with the general punctuation hypothesis is non-normal in nature because of the frictions in the policy system that curtail the smooth processing of policy signals into policy outputs. The resulting distribution diverges from normality in three important and predictable ways (Jones, 2003, 2017). First, the distribution shall exhibit a large peak, reflecting the fact that the policy system is for the most part stable, with little change in issue attention across periods. Second, the distribution will have fat tails, because larger punctuations relating to significant changes to the policy agenda are expected to occur from time-to-time. Third, the distribution shall exhibit dropped shoulders, because the cognitive and institutional frictions in the system prevent moderate policy-agenda changes. Distributions with these characteristics are leptokurtic in nature. If the ECB is similar to other policy-making systems, the general punctuation hypothesis should hold:

H_1: *If the information-processing mechanisms of the ECB are inefficient, the distribution of changes to the ECB policy agenda will be leptokurtic in nature.*

As alluded to above, when a policy system is relatively efficient at information processing, the normally distributed policy signals received are responded to in a proportional manner, and the resulting distribution of policy responses will approximate a normal distribution (Jones and Baumgartner, 2005; Padgett, 1980). Essentially a null finding in this case is informative, and suggests that frictions in the system are minimised allowing for a relatively free flow of information from

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input signals to output policies. This leads to the following null hypothesis:

H_0: *If the information-processing mechanisms of the ECB are efficient, the distribution of changes to the ECB policy agenda will be normal in nature.*

While H_1 and H_0 help us categorise ECB policy-agenda dynamics, in order to conclude the ECB is different to other information-processing systems, we need to directly compare it to such systems. Following Epp (2017), we consider different policy-system types in our comparison - some based on market structures and others based on institutionalised decision-making processes. Market-based systems are expected to be more efficient at processing information (and thus less subject to punctuated equilibrium dynamics) when market participants are independent, diverse, and use private judgment to make decisions (Surowiecki, 2005). In such settings, individual mistakes are less likely to have systemic consequences as fewer errors accumulate, and institutional frictions are lower, meaning information is better processed.

Institutionalised policy-making systems on the other hand usually involve group decision-making processes, which are expected to generate punctuated equilibrium dynamics. Group decision-making tends to be more susceptible to the negative effects of dependence among organisation members, similarity in their world views, and the use of decision heuristics. These factors act as impediments to efficient information processing and can lead to punctuations when left unchecked. Most if not all information-processing systems lie somewhere between the two extremes described above. As Epp (2017) states: "If [policy-making] organizations were capable of processing information more comprehensively, then policy change would proceed more smoothly over time, with policies seamlessly up-

dating in response to shifting environmental cues rather than alternating between periods of under and overresponse". It is our contention that central banks like the ECB will stand out compared to other policy-making systems, due to the significant efforts put into information processing, the information-sharing structures present in the organisation, and the existence of strong reputational concerns that encourage proportional responses to policy challenges.

H_2: *The distribution of ECB policy-agenda changes are less leptokurtic than to other policy-making systems.*

4 Data and methods

In order to capture the policy agenda of the ECB, it is necessary to create a new corpus of ECB Governing Council speeches. We focus on the time period from January 1999 when the ECB was launched, to June 2018 when the study was conducted. The Governing Council consists of an Executive Board with a President and Vice-President and three other members. The Executive Board is joined by the Governors of the National Central Banks (NCBs) of the 19 Euro area countries to form the Governing Council. Speeches by the NCB Governors are included in the analysis, because they are intimately involved in setting ECB policy as Governing Council members, and are tasked with explaining ECB decisions and providing forward guidance to domestic audiences. The message delivered by NCB Governors in their speeches is thus very much part of the coordinated effort to communicate ECB policy choices and affect market expectations. English-language speeches from the Executive Board were extracted from the ECB website[2], while

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[2] https://www.ecb.europa.eu/press/

English-language speeches from the rest of the Governing Council were extracted from the home pages of each NCB[3].

Once the set of speeches of interest was identified, the next step in the analysis involved processing the raw text to create a representation suitable for topic modelling. Speeches available in PDF format were first converted to plain-text files using standard Optical Character Recognition (OCR) software[4]. They were then split into individual paragraphs to provide short coherent document units for analysis in our topic model. The justification for splitting longer speeches into shorter paragraph-based segments is that paragraphs can be thought of as distinct sections of a larger text, usually dealing with a single theme or topic. Each paragraph represents a "document" in the context of the topic modelling algorithm. We apply the pre-processing steps descried in Online Appendix A to each of the 78 quarterly "time windows" represented in the overall corpus. This results in a corresponding set of 78 document-term matrices capturing the set of speeches made by the ECB Governing Council in each quarter between January 1999 and June 2018.

Table 1 provides an overview of the speech corpus. In total, we analyse 3,081 speeches, which are broken down into 101,145 individual paragraphs. We see that there is significant variation in the number of speeches available across different central banks, with a high number of contributions from the ECB and countries

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[3]Multi-lingual topic modeling is a complex problem that has yet to be convincingly addressed in the literature. As a result, we limit the corpus to original and officially translated English-language speeches to aid comparison and analysis. While this choice introduces a potential source of bias in the analysis, the lingua franca of central banking is English meaning that overall coverage across jurisdictions is fit for task. Furthermore, ECB communications policy requires that speech texts are translated and publicly released before a speech is given to avoid providing the live audience with privileged access to market-moving information that they might use to their advantage.

[4]ABBYY FineReader: https://www.abbyy.com/en-eu/finereader/

like Germany, Spain, Ireland, Italy, and Portugal. In contrast, countries like Belgium, Estonia, Lithuania, Slovakia, and Slovenia are less well represented in the corpus. This variation is a function of the fact that some NCB Governors are much more active than others in terms of public speeches, and some NCBs are much better at publishing speeches online than others. In Table 1 we detail the variation across a selection of central banks in the Euro system. A total of 50 distinct speakers are represented in the dataset, with 3 ECB Presidents, 3 ECB Vice-presidents, 13 Executive Board members, and 36 NCB Governors present. In the analysis that follows, we consider all speech paragraphs, despite the variation in observations across different constituent NCBs, because the inclusion of additional data improves topic model performance.

4.1 Topic modelling

The major methodological challenge we must confront in this project is how to detect and extract the institution-level policy agenda from the set of speeches made by Governing Council members at the individual level. Speeches, by their very nature are rather unstructured examples of text, and can vary considerably in their thematic content. Indeed, while there will be certain expectations about what central bankers should be speaking about, it is up to the speaker themselves and their speech-writing teams to decide on the exact content of a speech. In recent years, automated methods for exploring and classifying the content of texts in the form of topic models have been developed. Topic models attempt to discover the hidden thematic structure within an unstructured collection of text without relying on any form of hand-coding or training data. These methods offer the potential to sig-

Central Bank	No. of paragraphs	% of total
AT	733	0.72
BE	18 8	0.19
CY	1,123	1.11
DE	6,406	6.33
ECB	59,470	58.80
EE	393	0.39
EL	2,722	2.69
ES	5,637	5.57
FI	3,018	2.98
FR	639	0.63
IE	3,421	3.38
IT	12,822	12.68
LT	338	0.33
LU	620	0.61
LV	818	0.81
MT	415	0.41
NL	843	0.83
PT	1,395	1.38
SI	106	0.10
SK	38	0.04
Total	101,145	100

Table 1: Speech paragraphs per Eurosystem central bank.

nificantly reduce the effort required to measure policy-agenda dynamics typically associated with hand-coding efforts, and improve the reliability and replicability of such efforts.

Recently, Greene and Cross (2017) applied a new dynamic topic modelling approach to examine the policy agenda of the European Parliament (EP). This approach involves dividing a timestamped corpus into time windows of equal duration (*e.g.* three months), and then tracking the progression of automatically-extracted topics across these windows. In topic models based on latent Dirichlet allocation (Blei and Lafferty, 2006; Roberts et al., 2013), significant smoothing

of topic probabilities occurs across time windows, making it difficult to detect changes in these topics over time. In contrast, the Greene and Cross (2017) approach generates the topics for each window independently, resulting in topics that better highlight the *evolution* of issue attention over time. This is important for the task at hand, which is concerned with identifying the dynamic evolution of the ECB policy agenda when the vocabulary relating to a given policy agenda item can change over time.

The topic model here elaborates upon that implemented by Greene and Cross (2017) by including n-grams in our document representation – i.e, contiguous sequences of n words from a given document. This allows us to capture the technical terminology present in central bank communications and important concepts referred to via multi-term phrases (for instance, 'interest rates', 'quantitative easing', 'monetary policy strategy'). The process used to identify the relevant n-grams and a comparison between the n-gram based approach used and a simpler unigram-based approach is described in Appendix B.

5 Analysis and results

5.1 The policy agenda of the ECB

Before examining whether punctuated equilibrium dynamics best describe the ECB policy agenda, we provide a broad overview of the latent policy themes revealed in our corpus by our dynamic topic model. Our first task is to identify the substantive policy area that each topic relates to so that an appropriate topic label can be manually assigned. This is done by considering the *topic descriptors*

associated with each topic (here corresponding to the top ranked terms, including relevant n-grams), and examining how they change over time. The degree to which substantively interesting topics can be identified from these sets of terms informs us about the face validity of the results produced. In practice the first $10 - 20$ terms are considered, but for illustrative purposes, Table 2 lists the top-5 terms associated with the 56 topics detected by our model, along with the substantive label applied to each topic[5]. As can be seen, a rich and varied set of policy priorities are discussed by ECB Governing Council Members. We can see topics relating to a whole host of central bank functions, including those relating to executing monetary policy, those related to the financial crisis and its aftermath, and those relating to economic developments more generally. Interestingly, we see a mix of policy levels discussed, with the policy agenda divided between issues at the global level ('World economy', 'Global imbalances'), the European level ('Euroarea economic performance','EMU institutions & regulation'), and the national level ('Italian government finances', 'Bailout programmes & Greece').

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[5]Details on model parameterisation and the manner in which the optimal number of topics was determined are provided in Online Appendix B.

Table 2: Top-5 n-grams associated with each topic.

Rank	Economic growth	Financial system	Monetary policy	Bank lending	The Euro & its international role	Inflation	EU integration	Accession & European imbalances
1	growth	financial	monetary_policy	banks	euro	inflation	europe	countries
2	recovery	system	strategy	capital	currency	inflation_expectations	european	accession
3	economic	institutions	decisions	assets	currencies	prices	political	economies
4	demand	markets	price_stability	bank	single_currency	price	european_union	country
5	gdp	sector	single	loans	dollar	medium_term	eu	debt

Rank	Market characteristics	GDP & Government finances	Global imbalances	European economic integration	Labour productivity	Payment systems & clearing	ECB governance & communication	Economic conditions
1	market	gdp	global	integration	labour	payment	ecb	economic
2	participants	expenditure	economies	european	unemployment	payments	governing_council	activity
3	securities	net	emerging	process	employment	systems	decisions	policies
4	competition	ratio	imbalances	political	workers	retail	strategy	conditions
5	markets	government	international	integrated	wage	services	members	governance

Rank	Monetary analysis	Euro area economic performance	Asset-purchasing programs	Post-crisis global finance	Credit & lending	Banking system	Prices & inflation	Fiscal policy & fiscal rules
1	monetary	euro_area	asset	crisis	credit	banking	prices	fiscal
2	analysis	united_states	purchases	lessons	lending	system	price	rules
3	developments	gdp	purchase	global	bank	sector	oil	consolidation
4	m3	average	programme	financial	loans	bank	consumer	fiscal_policies
5	assessment	developments	securities	management	firms	cross_border	increase	stability_and_growth_pact

Rank	Statistics	Euro changeover	Communication & transparency	Crisis response toolkit	Price stability	Eurosystem structure	Role of Central Banks	Interest rates
1	statistics	banknotes	information	measures	price_stability	eurosystem	central_bank	interest_rates
2	statistical	coins	public	non_standard	objective	collateral	central_banks	rates
3	accounts	cash	communication	support	medium_term	framework	financial_stability	interest_rate
4	ecb	euro	governing_council	exit	definition	operations	independence	negative
5	conference	changeover	transparency	governments	primary	operational	monetary	rate

Rank	Role of the state & society	World economy	Italian economy	Role of money	Basel II	Exchange rates	Supervisory authorities	Savings & investment
1	social	economy	italy	money	basel_ii	exchange_rate	supervisory	investment
2	society	world	germany	value	framework	exchange_rates	supervision	capital
3	work	uncertainty	france	electronic	capital	currencies	supervisors	savings
4	life	italian	united_states	central_bank	supervisors	dollar	authorities	financing
5	state	recovery	industrial	trust	committee	target	cooperation	demand

Rank	Risk management	Liquidity & money markets	EMU institutions & regulation	Accession & economic convergence	Italian government finances	ESRB	International role of currencies	Economic policy & its effects
1	risks	liquidity	national	eu	esrb	trillion	international	rate
2	risk	operations	level	member_states	macro_prudential	lire	currency	average
3	financial_stability	money_market	european	convergence	eu	tax	role	annual
4	credit	collateral	policies	accession	recommendations	net	dollar	reference
5	risk_management	funding	common	process	systemic_risk	revenue	currencies	value

Rank	World trade	Bailout programmes & Greece	Labour & employment	Financial markets	Law & regulation	Bank resolution	SMEs	Central bank policies
1	trade	programme	productivity	markets	public	resolution	firms	policy
2	world	greece	labour	financial	law	banking_union	small	uncertainty
3	economies	greek	growth	competition	government	bank	italian	policies
4	china	government	services	development	rules	ssm	production	expectations
5	exports	reforms	reforms	investors	authorities	framework	enterprises	macro_prudential

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5.2 Higher-level topic clustering and validation

The unsupervised nature of our topic model implies that it is necessary to validate the results in order to ensure the model is detecting coherent and useful latent characteristics of our corpus. Inter-topic semantic validity is a useful concept to invoke in this context. Semantic validity refers to the degree to which the relationships between categories of text (topics) correspond to the meanings these categories have for particular readers (Krippendorff, 2012). As stated before, each topic in our results has a set of most-related terms. For our results to demonstrate semantic validity, we should observe an overlap of the sets of terms describing semantically related topics.

To assess the inter-topic semantic validity of the results, we examine the extent to which any meaningful higher-level clusters exist among the 56 dynamic topics. The intuition in doing so is that topics in economic policy-making are very much interrelated, and this should be reflected in the uncovered semantic relationships between the topics we extract from the corpus. Figure 1 graphically displays the higher-level clusters detected in the form of a dendrogram tree diagram[6]. Following the interpretation provided in Quinn et al. (2010), the lower the height at which any two topics are connected in the dendrogram, the more similar their term usage patterns in ECB speeches.

Based on this approach, we distinguish between 10 higher-level groupings of interest, which make intuitive sense and are highlighted in Figure 1. There is a clear hierarchical relationship between the 6 topics that relate to the role of central banks (red box). The Euro-crisis and its effects on Government finances is also

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[6]See Appendix C for a detailed description of the methodology used.
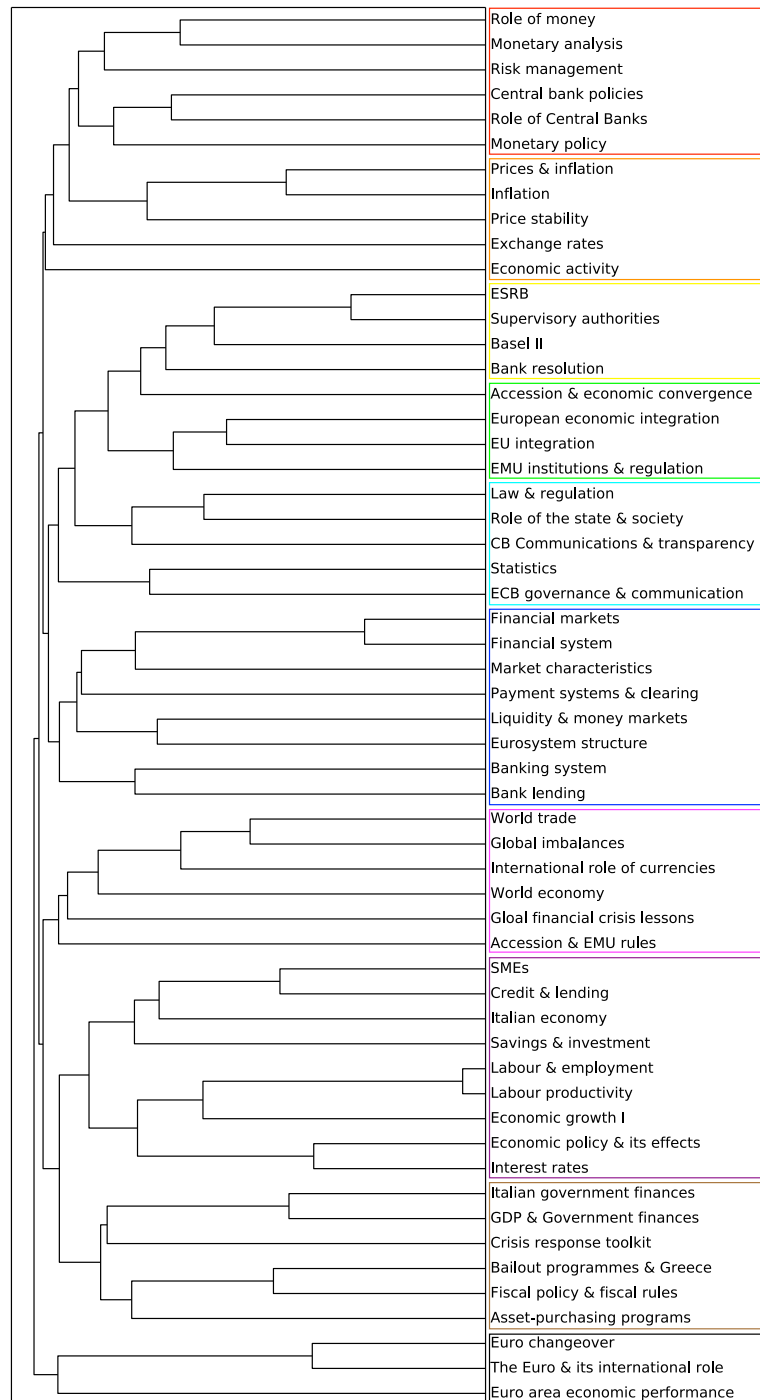
Figure 1: Dendrogram of the average linkage hierarchical agglomerative clustering of 56 dynamic topics, highlighting 10 higher-level groupings of interest.

represented (brown box), with topics including 'GDP & Government finances', 'Crisis response toolkit', and 'Bailout programmes & Greece'. Another cluster of interest relates to financial supervision (yellow box), which includes topics relating to the 'ESRB', 'Basel II', and 'Banking resolution' amongst others. A final cluster of interest (dark purple box) containing topics relating to the real economy, covering 'SMEs', 'Credit & lending', and 'Labour & employment', among others. The fact that these higher-level clusters make intuitive sense given substantive knowledge of what the ECB does provides evidence that our dynamic topic-modeling approach is capturing semantically valid topics.

Figure 2 shows how attention to different topic categories varies over time. Topic categories such as the 'Real economy' and the 'Financial system' are regularly discussed across the entire period, whereas crisis-related topic categories such as 'Bank balance sheets' are much more prominent during the apex of the Eurocrisis from 2012. All of this suggests that the topic model is detecting latent themes in our text corpus that are valid and of substantive interest to those seeking to understand the ECB policy-making process. It also unveils an interesting variation in the ECB policy agenda that warrants further study. We will use these higher-level clusters of topics in the next section to assess our expectations relating to the determinants of ECB policy-agenda dynamics.

5.3 The dynamics of ECB communications policy

In this section we seek to establish the degree to which the ECB policy agenda can be characterised by punctuated equilibrium dynamic. Our focus is on the first differences in the percentages of speech paragraphs dedicated to a given policy-
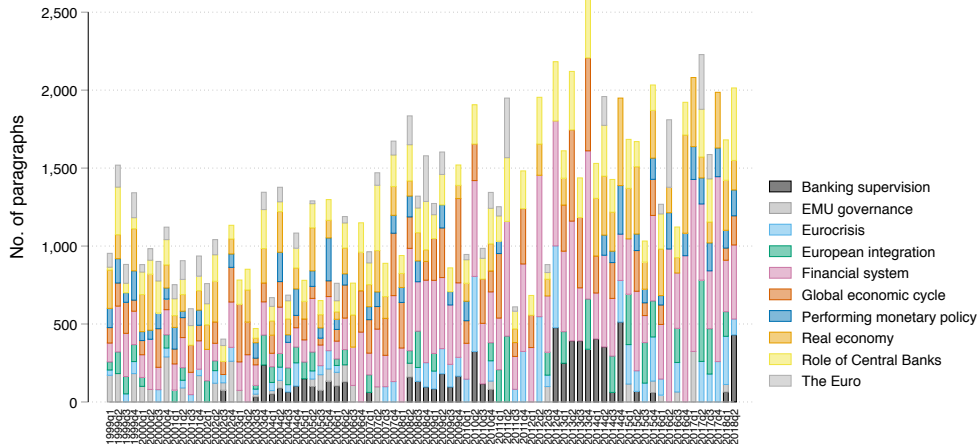
Figure 2: Number of speech paragraphs dedicated to each topic category in each quarter in the dataset.

agenda category, as identified in Figure 1 (Breunig and Jones, 2011). For example, if 10% of all speech paragraphs at time t is addressed to topics in the 'Eurocrisis' category and this changes to 15% at time $t + 1$, then the first difference between these two periods would be 5%.

Recall that H_0 states that changes in the percentage of speech paragraphs dedicated to a policy-area will be normally distributed, while H_1 states that the same distribution will be leptokurtic in nature. To assess the levels of leptokurtosis in our distribution, we use L-kurtosis statistics, which capture kurtosis while being less susceptible to extreme values and small case numbers (Breunig and Jones, 2011). This statistic is bounded between 0 and 1, with higher scores indicating distributions with fatter tails, and thus more punctuations. For comparison, a Gaussian normal distribution, which is associated with proportional policy agenda change, has an approximate L-kurtosis score of 0.123.

Table 3 presents L-kurtosis statistics for each of the topic categories of inter-

Topic category	L-kurtosis	Central Bank	L-Kurtosis
European integration	0.084	ECB	0.18
Role of Central Banks	0.114	NL	0.21
Global economic cycle	0.125	IE	0.24
Real economy	0.145	ES	0.25
Financial system	0.152	DE	0.27
Performing monetary policy	0.161	FI	0.27
EMU governance	0.181	MT	0.27
The Euro	0.192	IT	0.3
Eurocrisis	0.195		
Banking supervision	0.198		
All topic categories	0.171		

Table 3: L-Kurtosis statistic by topic category and Euro system central bank

est. The L-kurtosis statistic for all topic categories is 0.171, which is somewhat above that of a Gaussian normal distribution, but as shall be seen below, a good deal lower than that observed for most institutionalised policy systems. This suggests that the ECB is a relatively efficient information-processing system. When we look at the L-kurtosis statistics for each of the topic-categories, some interesting variation emerges. The topic-categories relating to 'European integration' and the 'Role of Central Banks' exhibit less kurtosis than a Gaussian normal distribution, while topic categories we would expect to exhibit punctuations like the 'Eurocrisis' and 'Banking supervision' are more leptokurtic[7].

To further investigate for non-normality, Figure 3 presents histograms of the

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[7]One might suspect that the results presented here are driven by the methodological approach because the manner in which the topic model identifies attention shifts predisposes it to detecting proportional change rather than punctuations by smoothing across time periods. To assess if this is the case, we replicate the above analysis but with the speeches made by Members of the European Parliament (MEPs) as our communications of interest. The L-kurtosis statistic associated with MEP speeches is 0.277. This result suggests that MEP attention is more subject to punctuated equilibrium dynamics than ECB speeches. This makes sense when one considers how the Parliamentary system is likely to exacerbate cognitive and institutional frictions rather than ameliorate. Greene and Cross (2017) also demonstrate that the NMF-based approach employed here is better at capturing topic evolution over time than the more common LDA-based approachs found in the literature.

distributions in question along with a Gaussian normal distribution for comparison. We include a histogram of all combined paragraphs in the first panel to demonstrate policy-agenda dynamics at the policy-system level. Initial impressions suggest that changes to the policy agenda are relatively normally distributed in the vast majority of policy areas, suggesting that emphasis on policy-agenda items tends to evolve in a proportional manner. There are also some hints at high central peaks in some of the distributions in question ('EMU governance' and 'Performing monetary policy'), suggesting a certain amount of stability in these policy areas, but long tails appear to be less of an issue, which indicates relatively few outlier punctuations. Interestingly, most of the distributions have well-populated shoulders, suggesting that the general punctuation hypothesis prediction that moderate policy changes are rare does not seem to hold for ECB communications policy[8].

Table 3 also presents statistics comparing the communications strategies of the different Euro area central banks in terms of leptokurtosis. We limit the analysis to the ECB and NCBs for which a sufficient number of paragraphs exist across time for the L-kurtosis statistics to be meaningful. The results demonstrate that the ECB has the lowest L-kurtosis statistic at 0.18, suggesting it is the part of the policy system least susceptible to punctuated equilibrium dynamics. Of the remaining NCBs, De Nederlandsche Bank has the next lowest L-kurtosis score (0.21), followed by the Central Bank of Ireland (0.24) and the Banco d'España (0.25). The Bundesbank, the Bank of Finland, and Central Bank of Malta have the same level of leptokurtosis (0.27), and the Banca d'Italia has the highest score (0.3). The fact that the ECB appears to be less susceptible to punctuated equi-

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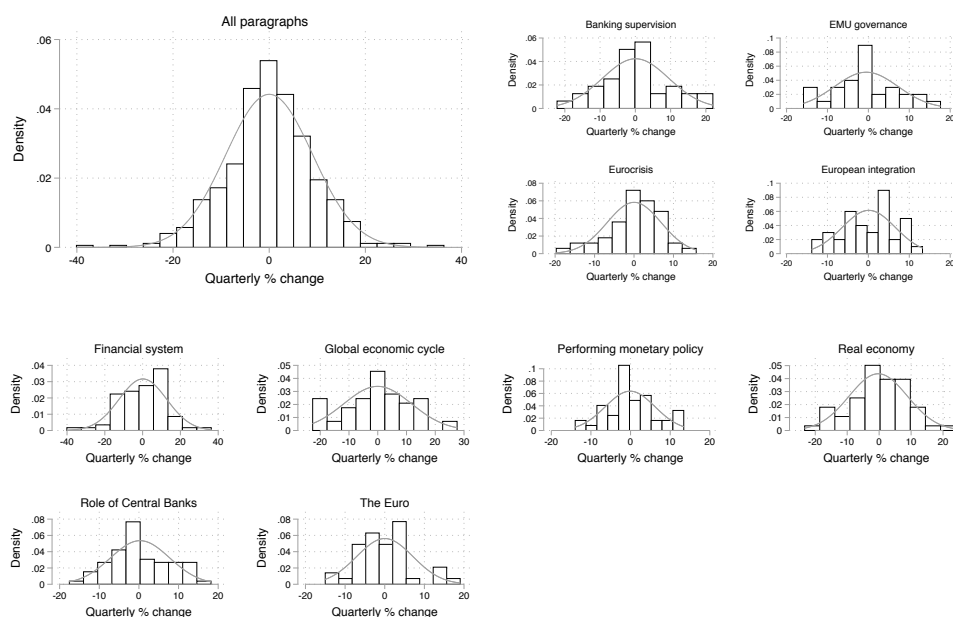[8]Appendix D provides further normality testing for the distributions of interest.

Figure 3: Distribution of quarterly changes in the percentage of all speech paragraphs related to each policy category.

librium dynamics than individual NCBs corresponds to its position at the centre of the Euroarea information-processing system, and the reputational pressure it experiences interacting with markets as the sole setter of monetary policy.

5.4 Information processing in other policy contexts

The key finding in the previous section is that ECB communications policy appears to evolve in a proportional manner. Table 4 demonstrates that when compared to other information processing systems, the ECB appears to be relatively efficient in processing policy-information and adjusting communications content accordingly.

Policy context	L-kurtosis	Type_label	Source
Dow-Jones	0.18	Market	Epp (2017)
FTSE 100	0.233	Market	Epp (2017)
S&P 500	0.176	Market	Epp (2017)
CAC	0.183	Market	Epp (2017)
DAX	0.193	Market	Epp (2017)
Nikkei	0.182	Market	Epp (2017)
IBEX	0.19	Market	Epp (2017)
IPC	0.198	Market	Epp (2017)
Airline yields (regulated market)	0.425	Market	Epp (2015)
Airline yields (deregulated market)	0.235	Market	Epp (2015)
Free floating FX	0.181	Market	Epp (2017)
Soft peg FX	0.389	Market	Epp (2017)
Hard peg FX	0.539	Market	Epp (2017)
US	0.512	Budget	Jones et al. (2009)
US (States average)	0.402	Budget	Breunig & Koski (2006)
EU	0.28	Budget	Citi (2013)
France	0.505	Budget	Jones et al. (2009)
Germany	0.456	Budget	Jones et al. (2009)
UK	0.319	Budget	Jones et al. (2009)
Belgium	0.611	Budget	Jones et al. (2009)
Denmark	0.421	Budget	Jones et al. (2009)
Denmark (local)	0.363	Budget	Jones et al. (2009)
Canada	0.379	Budget	Jones et al. (2009)
China (region average)	0.87	Budget	Chan & Zhao (2016)
Russia - partly free (1999-2004)	0.449	Budget	Baumgartner et al. (2015)
Russia - not free (2005-2007; 2011-2015)	0.514	Budget	Baumgartner et al. (2015)
Finland	0.2	Budget	Fagan et al. (2017)
Slovakia	0.26	Budget	Fagan et al. (2017)
Slovenia	0.26	Budget	Fagan et al. (2017)
Hungary	0.29	Budget	Fagan et al. (2017)
Greece	0.32	Budget	Fagan et al. (2017)
Portugal	0.35	Budget	Fagan et al. (2017)
Poland	0.35	Budget	Fagan et al. (2017)
Denmark	0.35	Budget	Fagan et al. (2017)
Norway	0.36	Budget	Fagan et al. (2017)
Netherlands	0.36	Budget	Fagan et al. (2017)
Spain	0.36	Budget	Fagan et al. (2017)
Australia	0.39	Budget	Fagan et al. (2017)
France	0.42	Budget	Fagan et al. (2017)
US	0.43	Budget	Fagan et al. (2017)
Luxembourg	0.46	Budget	Fagan et al. (2017)
UK	0.47	Budget	Fagan et al. (2017)
Czech Republic	0.48	Budget	Fagan et al. (2017)
Austria	0.48	Budget	Fagan et al. (2017)
Switzerland	0.56	Budget	Fagan et al. (2017)
Canada	0.57	Budget	Fagan et al. (2017)
Sweden	0.57	Budget	Fagan et al. (2017)
Germany	0.63	Budget	Fagan et al. (2017)
Italy	0.67	Budget	Fagan et al. (2017)
Belgium	0.331	IO	Alexandrova et al. (2012)
European Council agenda	0.28	IO	Lundgren et al. (2017)
United Nations	0.3	IO	Lundgren et al. (2017)
African Union	0.26	IO	Lundgren et al. (2017)
EU 2	0.26	IO	Lundgren et al. (2017)
OAS	0.31	IO	Lundgren et al. (2017)
OIC	0.21	IO	Lundgren et al. (2017)
Bill introduction (US House)	0.23	Legislative	Baumgartner et al. (2009)
Bill introduction (US Senate)	0.26	Legislative	Baumgartner et al. (2009)
Danish bill introduction	0.33	Legislative	Baumgartner et al. (2009)
Hearings (US House)	0.27	Legislative	Baumgartner et al. (2009)
Hearings (US Senate)	0.25	Legislative	Baumgartner et al. (2009)
US Executive orders	0.383	Executive	Boydstun (2013)
New York Times stories	0.31	Media	Baumgartner et al. (2009)
Belgian TV coverage	0.36	Media	Martin & Streams (2015)
Global health commitments	0.449	Health & welfare	Jensen (2009)
Welfare policy		Health & welfare	

Table 4: L-Kurtosis statistic by policy context

In budget-making systems for instance, punctuated equilibrium dynamics seem to be the rule rather than the exception (Baumgartner et al., 2015; Breunig and Koski, 2006; Chan and Zhao, 2016; Citi, 2013; Fagan et al., 2017). All of the budget-making systems considered in Table 4 display significantly more leptokurtosis than ECB communications policy, lending support to H_2. Also in line with H_2, international organisations (Alexandrova et al., 2014; Lundgren et al., 2017), legislative and executive systems (Baumgartner et al., 2009), media agendas (Baumgartner et al., 2009; Boydstun, 2013), and health and welfare policy (Jensen, 2009; Martin and Streams, 2015) exhibit more leptokurtosis than the ECB. Indeed, it is only in market-based information-processing systems like stock markets and free-floating exchange rates that we observe punctuated equilibrium dynamics similar to those seen in ECB communications policy. As soon as markets become more regulated or institutionalised (airline yields and pegged exchange rates for example), punctuated equilibrium dynamics start to emerge.

6 Conclusion

This study links the literature on central bank communications policy to that on policy-agenda dynamics. It outlines the general punctuation hypothesis of policy-agenda dynamics and assesses its relevance in the context of central bank communications policy. We argue that a combination of central bank independence, the narrow mandate, the information-sharing and research structures, and the reputational concerns of the ECB lead it to proportionally adjust policy as required. These factors minimise the negative effects that cognitive and institutional frictions tend to generate in other contexts. Our empirical findings support this argu-

ment, with the distribution(s) of ECB policy-agenda changes considered exhibiting much lower levels of leptokurtosis than other comparable policy-making systems. Indeed, in terms of kurtosis, the distributions observed are closer in nature to those observed in systems that efficiently process policy-relevant information. This suggest that in at least some policy contexts, it is possible to design policy-making institutions in a way that minimises punctuated-equilibrium dynamics.

To conclude, we do not argue that the general punctuation hypothesis is falsified or not applicable in the context of ECB communications policy. Instead, we argue that unlike many of the policy-making systems considered in the literature, the ECB, and central banks more generally are designed to address the mechanisms that lead to the emergence of punctuated equilibrium dynamics. As a result of these institutional design choices, proportional policy responses dominate – a situation that is quite different to most other policy-making systems. We hope that our findings inspire further research into why this is the case. In particular, disentangling the effects of independence, mandate, information-processing mechanisms, and reputational concerns would be productive. We show here that all these factors contribute to proportional policy adjustment, but their relative contribution and the conditions under which they matter remain unexplored. Our research represents a first attempt to study central banks from a policy-agenda dynamics perspective, and suggests that these policy-making institutions are interesting contexts in which to further test the ideas found in this literature.

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