A Supply and Demand Model of Political Party Growth

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Abstract

In this paper, we extend an existing model of political party growth by including concepts suggested by current research. In the original model, party recruitment was modelled by analogy with the spread of an infection, describing the demand-led requirements of party leaders. We include a second mode of recruitment, the supply mechanism, where people join because of the party's popularity. We model popularity using soft variables to capture the concepts of political legitimacy and the personal political benefits of party membership. The model is developed using a modular structure that helps elucidate the feedback structure between the population variables and the soft variables and enables the effects of the soft variables to be separated from their potential measures. We apply the model to two data sets to demonstrate improvements over the original model in both data fitting and the explanatory narrative.

Key Words: Social diffusion, political parties, epidemics, soft variables, modules, political legitimacy

1 Introduction

Most countries rely on political parties to form governments, select leaders, determine a legitimate political identity and form policy. In democratic countries, parties depend on *members* to help them attain power, finance the party, campaign in elections, and provide the legitimacy required to convince an electorate to vote for them. Thus, large party memberships can be advantageous, and party leaders take membership growth seriously. As such, there is an increasing body of research on why parties grow and decline (Gauja, 2015; Norris, 2002; Scarrow, 2014; Vittori, 2019; Whiteley and Seyd, 2002).

Theories concerning political party growth can be grouped into three broad areas: limits-to-growth, incentives that increase the *supply* of party members, and the party's need for political legitimacy resulting in its *demand* for members. Michels (1966) and Tan (1998) argue that as party size increases, specialisation increases and individual members are less able to find a meaningful role in the party. More members free-ride, benefitting from party membership without contributing, which places limits on party size, as is common in many organisations (Olson, 2009). Tan (1998) demonstrated these effects from the survey data of Janda (1980), showing that size can indirectly increase participation through increased party complexity. Thus, while free-riding limits party growth, its effects can be alleviated through wise party management.

Whiteley and Seyd (2002) assert that parties grow by offering incentives and benefits for party members. Such benefits may involve the hope of political influence, the choice of party leaders and candidates, electoral success for the party or favourable referenda outcomes (Achury, Scarrow, Kosiara-Pedersen, and Van Haute, 2020; Paddock, 2007). Thus, potential members find the party attractive and choose to join – the supply of new members. In more recent times, parties have increased benefits to members to attract new members and thereby improve party legitimacy (Dalton and Weldon, 2005; Scarrow, 2005; Scarrow and Gezgor, 2010). The new members are encouraged to be active and help build the party's political legitimacy to the electorate through their activities, e.g. canvassing in the local community (Poguntke and Scarrow, 1996; Whiteley and Seyd, 2002).

In addition to the supply of new members, Whiteley and Seyd (2002) also discuss the importance of the parties' demand for new members as a larger party carries more political legitimacy. This demand often takes the form of deliberate recruitment campaigns involving party members and publicity. Campaigns may be scaled back or stopped entirely if the party leaders feel they have achieved a reasonable level of legitimacy or if some electoral goal has been achieved. Activists become involved in personal recruitment, and thus, parties need to ensure a healthy ratio of activists to free-riders (Norris, 2002). Additionally, the activists' work in building legitimacy can increase the effectiveness of direct recruitment. Sometimes, however, it is sufficient to build legitimacy through party size, making the activists' role less critical (Whiteley and Seyd, 2002).

Although all the theories mentioned above are supported by quantitative evidence, none involve dynamic modelling. Using some of these theories, Jeffs, Hayward, Roach, and Wyburn (2015) proposed a population model to explain party growth by analogy with the spread of a disease, referred to as the Limited Activist Model. Activists were viewed as operating in a way analogous to infectives, recruiting people from a susceptible population. The free-riders in the party were treated as a separate category, and their presence relative to activists influenced the ability of the party to make new members active. The model restricted growth to the demand-side and assumed members left at a constant rate. The model explained historic data favourably, but there were several instances where growth patterns changed due to changes in political legitimacy, which were not included in the model. Although reasonable narratives were produced, the absence of supply-side growth changes to political incentives, benefits, and legitimacy limits the model's explanatory power.

In this paper, we extend the Limited Activist model of Jeffs et al. (2015) to include recruitment by supply and the influence of benefits and political legitimacy on recruitment and retention. We aim to produce a richer political narrative to help explain historical party data and inform choices for political leaders who wish to grow parties and increase their influence. Firstly, we will express the Limited Activist Model in system dynamics, linking the model assumptions to feedback loops. Secondly, we will extend the model using modules to capture properties of political legitimacy and personal political benefits and their connection with the population variables. This approach will enable the concepts of *legitimacy* and *benefits* to be modelled as encapsulated soft variables whose interaction with other model elements is independent of their potential measures (Hayward, Jeffs, Howells, and Evans, 2014). Thirdly, we apply the extended model to two data sets used by Jeffs et al. (2015) and examine improvements in data fitting and the resulting narrative of growth and decline.

2 Population Model

The Limited Activist model of Jeffs et al. (2015) was constructed by analogy with the spread of a disease using the following six assumptions:

1. The population is disaggregated into party members and non-party members. Party members are divided into activists A_T and inactive members M. This latter group are free-riders who do not participate in activities that build up the party but may receive benefits from membership and be a drain on resources. Activists make a positive contribution to the political and organisational life of the party. There are two types of activists: those who actively recruit by word-of-mouth I and those who do not A. Thus, $A_T = I + A$. The non-party members are divided into susceptibles S, those open to the party because of their political persuasion, and the hardened H, those sufficiently opposed to the party that they would never become members. Thus, the total population $N = H + S + I + A + M$, and the party $P = I + A + M$.

2. The recruiting activists take on the role of the infectives in spreading a disease through a susceptible population, feedback loops `Rp1` and `Bp2`[1], Figure 1, and become non-recruiting activists after a given duration, loop `Bp3`. These loops form the classic SIR construction (Sterman, 2000). The non-recruiting activists become inactive members after a period generally longer than the *duration recruiting*, loop `Bp4`. The strength of the political "infection" is governed by the recruitment potential C_p, the equivalent of the reproductive ratio R_0 in epidemiology.

3. All recruits may become either type of activist or inactive members. This mechanism creates other feedback loops, not shown in Figure 1.

4. The number of contacts a recruiting activist can make depends on their duration active and not on the population density, as the transmission is by word-of-mouth. Thus, the probability of finding a susceptible depends only on the number of susceptibles and the population's size.

5. All activists influence the number of recruits who themselves become active according to the proportion of activists in the party $f = A_T/P$. That is, a more politically active party will have more politically active recruits.

6. Inactive members leave the party at a fixed rate, loop Bp5. They are open to re-joining, reflecting the ease with which members may lapse through non-renewal of membership. The completed model is a form of SIRS model with two types of "removed".

Jeffs et al. (2015) applied the model to four different growth and decline scenarios with varying degrees of success. We select two to demonstrate later the advantages of modelling with soft variables.

The most successful application of the model was to the post-war growth of the UK Labour Party, which resulted from a deliberate campaign to make every Labour voter a party member (Jefferys, 2007). Starting from 1947, two years after the general election of 1945, the model produces an excellent fit of the data[2], including the decline period during the 1950s,

[1] Loop names are annotated with "p" to indicate they connect population variables alone. This notation will distinguish them from loops between population and the external variable Political Legitimacy used in Section 3.
[2] All the data used in this paper is published by Audickas, Dempsey, and Loft (2019).

Figure 2, top curve[3]. The recruiting activists (bottom curve) follow a similar pattern to a disease, peaking in 1949. Jeffs et al. (2015) also show that the party continued to increase in activity up to 1951, only returning to 1947 levels in 1955, indicating that there are benefits to recruitment other than just party numbers. They concluded that a word-of-mouth hypothesis was consistent with the data and would provide a good narrative for an intentional recruitment campaign.

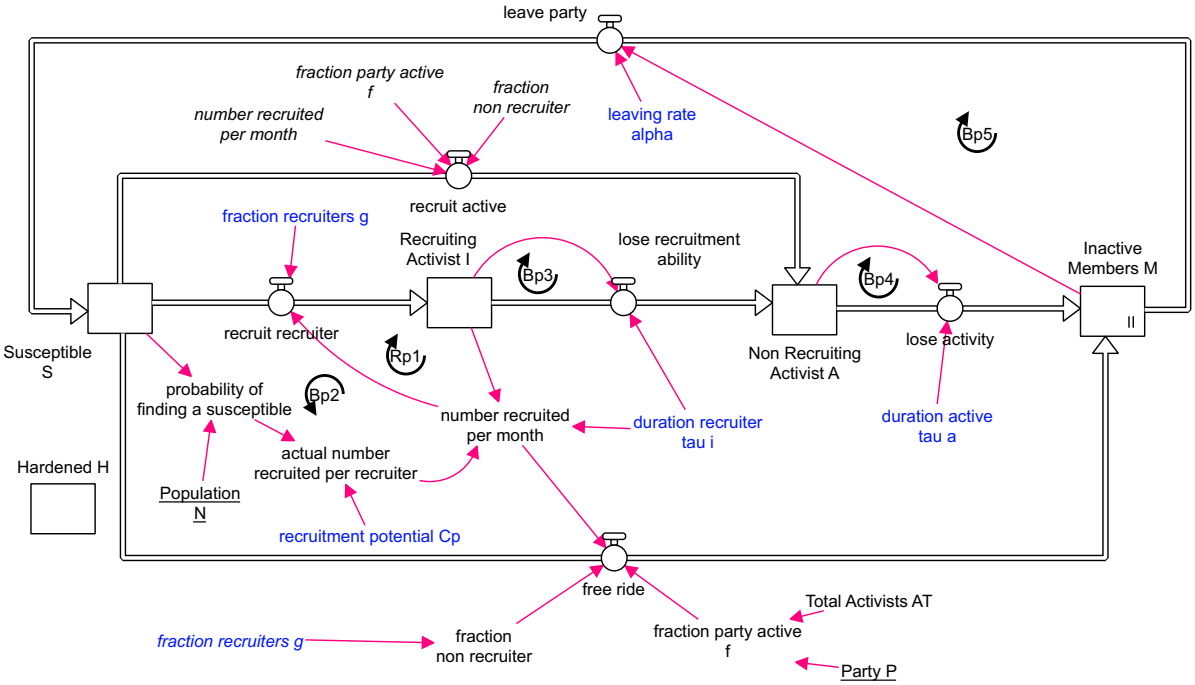

Figure 1: Limited Activist Model of political party growth.

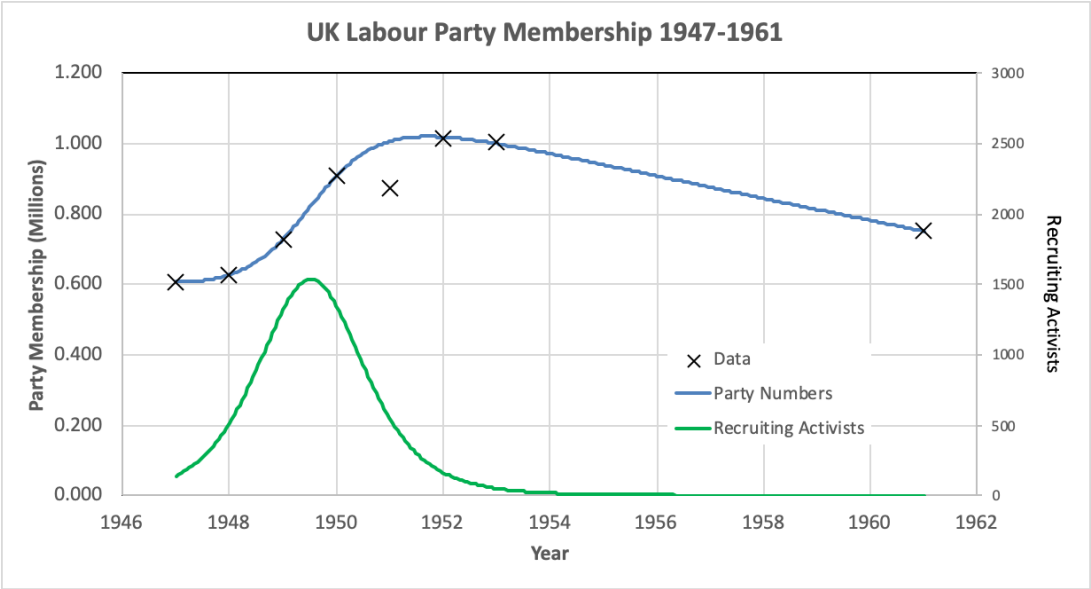

Figure 2: Limited Activist Model applied to the UK Labour Party 1947–1961. Parameter values are given in Appendix 1.

[3] The declining phase was estimated using an average rate based on the annual data, such that the model reaches the 1961 figure, the last year of decline (Jeffs et al., 2015). The 1951 value was excluded as the party suffered some temporary resignations due to losing the general election.

The second application was to the same political party, but from the 1990s onwards under the leadership of John Smith and his successor, Tony Blair. Following an unexpected election defeat in 1992, the Labour Party commenced a recruitment campaign in 1993 to rebuild a party depleted by earlier divisions and fight the 1997 election with a larger membership. Jeffs et al. (2015) applied the Limited Activist model to the membership data from 1993–2003, obtaining a good fit up to 1998 but failing to reproduce the data beyond that, Figure 3. The pre-election rise in party membership was too strong to enable a fit to the data points in the post-election decline, and the model's prediction of a resurgence from 2003 did not, in fact, occur. Jeffs et al. (2015) noted that the post-1998 data could only be replicated by a fall in recruitment potential coupled with a rise in leaving rate. Though they argued this was historically feasible due to the party achieving the legitimacy required to win the 1997 election, with membership offering fewer benefits to members, they noted the Limited Activist model had no means of expressing these features.

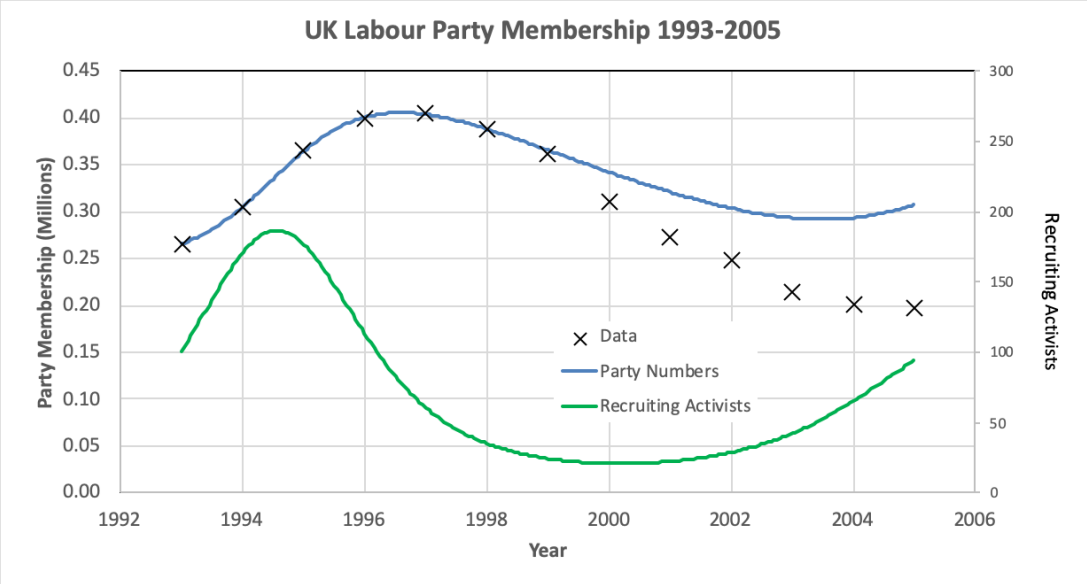

Figure 3: Limited Activist Model applied to the UK Labour Party 1993–2004. Parameter values are given in Appendix 1.

We now extend the Limited Activist model to include the concepts of political legitimacy and membership benefits as defined in the political literature (Dalton and Weldon, 2005; Paddock, 2007; Scarrow, 2005; Whiteley and Seyd, 2002). To make full use of these concepts, we will add to the model the supply mechanism for the recruitment of members, as noted by Tan (1998) and Whiteley and Seyd (2002), in addition to the existing demand mechanism described by the epidemiological contact. The extended model is required to replicate the Labour data from 1947-1961 and improve the data fit and political narrative for the Labour data from 1993-2005. We call the model the "Supply and Demand Model of Political Party Growth".

3 Supply and Demand Model of Political Party Growth

Model Overview

To extend the Limited Activist model, Figure 1, to include the supply of members, political legitimacy, and party membership benefits, we use two principles to guide the model construction: modularity and the correspondence principle. Modularity enables the population model and the two new concepts introduced to be understood and tested independently, which can help build confidence in the model construction (Hayward et al., 2014). The

correspondence principle, not previously referenced directly in Systems Dynamics, states that if the new additions to the model are removed, the extended model reproduces the original model[4]. If political legitimacy, membership benefits, and supply recruitment are removed in this new model, the Supply and Demand model will revert to the Limited Activist model.

The classic definition of political legitimacy is given by Lipset (1959): "the capacity of the system to engender and maintain the belief that the existing political institutions are the most appropriate ones for the society." In democratic societies, legitimacy is primarily granted by the people (Dogan, 1985) and captures the degree to which a party can be trusted with power at various levels. Legitimacy can be measured by the opinions of voters, their voting behaviour in elections and the performance of the party as perceived by the people and other agencies, such as the media (Von Haldenwang, 2016). From these measures, it is clear that some political parties are more legitimate than others at given points in time. Thus, political legitimacy is assumed to be a single stock.

There are many social benefits to political party membership, such as a source of friendships and a sense of purpose in life. However, we limit ourselves to *political* benefits for membership, as given in the introduction, as social benefits are beyond the boundaries of the model. We also refer to the concept as *personal* to emphasise that the benefits are for individuals rather than benefits to the party. We will use a single stock for *personal political benefits* as the concept has a sense of order. For example, the benefits of membership in the UK Labour Party increased during its 2015 leadership campaign as this was the first occasion on which all members were able to have an equal say in electing the leader. This benefit leads to a substantial increase in party membership.

There are two ways of generating political legitimacy: the size of the party (Whiteley and Seyd, 2002) and the work of party activists (Scarrow, 2005). Both party size and party activists are combinations of population stocks. Thus, there are causal links from the population module to political legitimacy. By contrast, personal political benefits are set by party leaders and political events. Therefore, no causal links lead to benefits, which will instead be set exogenously.

The supply of members to the party is influenced by the party's legitimacy and its benefits to members (Paddock, 2007; Whiteley and Seyd, 2002). We call the combination of legitimacy and benefits the *political attractiveness* of the party. Demand will also be influenced by this attractiveness, which serves to make the efforts of the recruiting activist more effective. However, demand will also decrease as political legitimacy increases towards a target set by the leaders (Whiteley and Seyd, 2002).

Modular Structure

We propose the following hypotheses linking the Limited Activist population model to political legitimacy and personal political benefits (see Figure 4):

1. The party seeks to increase the party membership to gain a target political legitimacy. Thus, the party *demands* members to achieve that legitimacy. This hypothesis is the balancing loop, `B1`.
2. The party builds political legitimacy through the work of activists in constituencies, canvassing, support for potential MPs, local government, etc. This mechanism also

[4] This principle is a general version of the correspondence principle used in physics.

assists the party in achieving a target political legitimacy, reducing demand for members, and slowing down the growth in activists and the party, loop B2.

3. Political legitimacy is built through activists and by party size, increasing the party's attractiveness. Thus, demand for members is more effective, and the recruiting activists grow the party faster, loop R3.
4. The building of legitimacy and the party's political attractiveness, described in hypothesis 3, increases the supply of new members, loop R4.
5. Growth in the party can increase the proportion of members who free-ride, which reduces the political legitimacy due to the adverse action of free-riders in party matters. The reduction in political legitimacy reduces the attractiveness of the party. Thus, both member supply and demand fall, reducing the party's growth, loop B5.
6. An increase in personal political benefits, such as achieving a successful election result or providing a leadership election, increases the party's attractiveness, making demand more effective and giving faster growth.
7. An increase in personal political benefits, and thus attractiveness, increases the supply of members.
8. An increase in personal political benefits helps increase member retention, reducing the leaving rate.

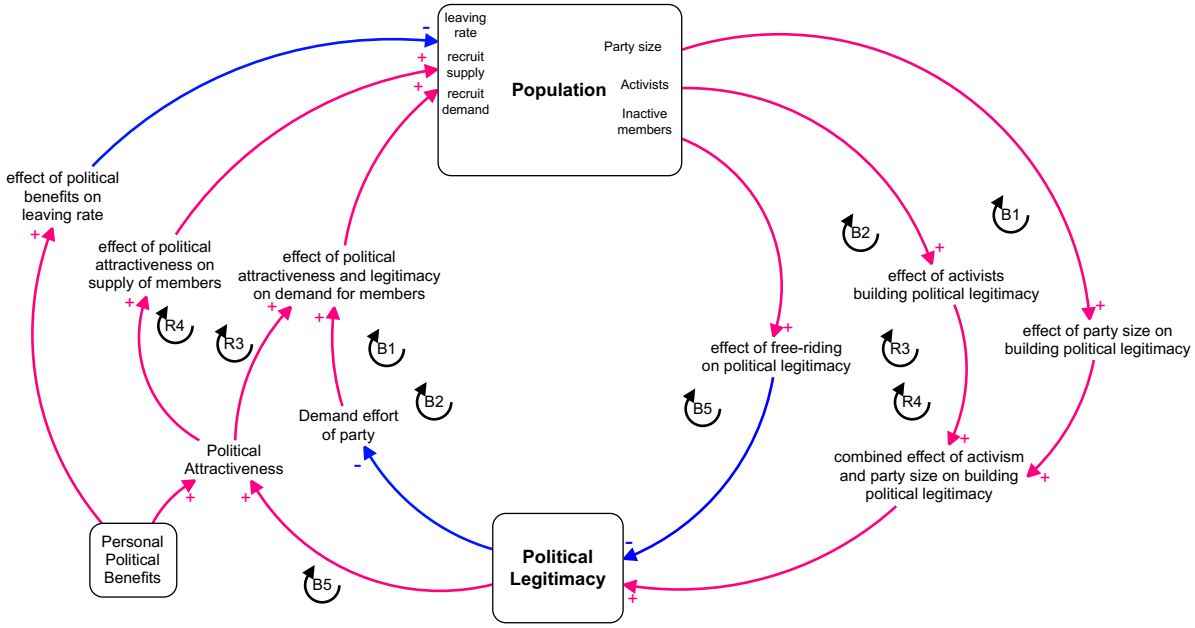

Figure 4: Modular structure of supply and demand model. Modules, indicated by rounded rectangles, contain one or more stocks. Other elements, indicated by name only, are modules that contain no stocks.

Modules with Stocks

The population module, Figure 4, contains the Limited Activist module, extended with flows representing supply, Figure 5. New members attracted to the party (supply) may become any of the three party member types in the same way as those recruited by the recruiting activists (demand). However, unlike the equivalent demand mechanism (hypothesis 5 of the Limited Activist model), the fraction of supply who become active, f_s, is independent of the party activists as they are not directly involved in the supply of members. The feedback loops of the Limited Activist model, Figure 1, are replicated in the population module, Figure 5.

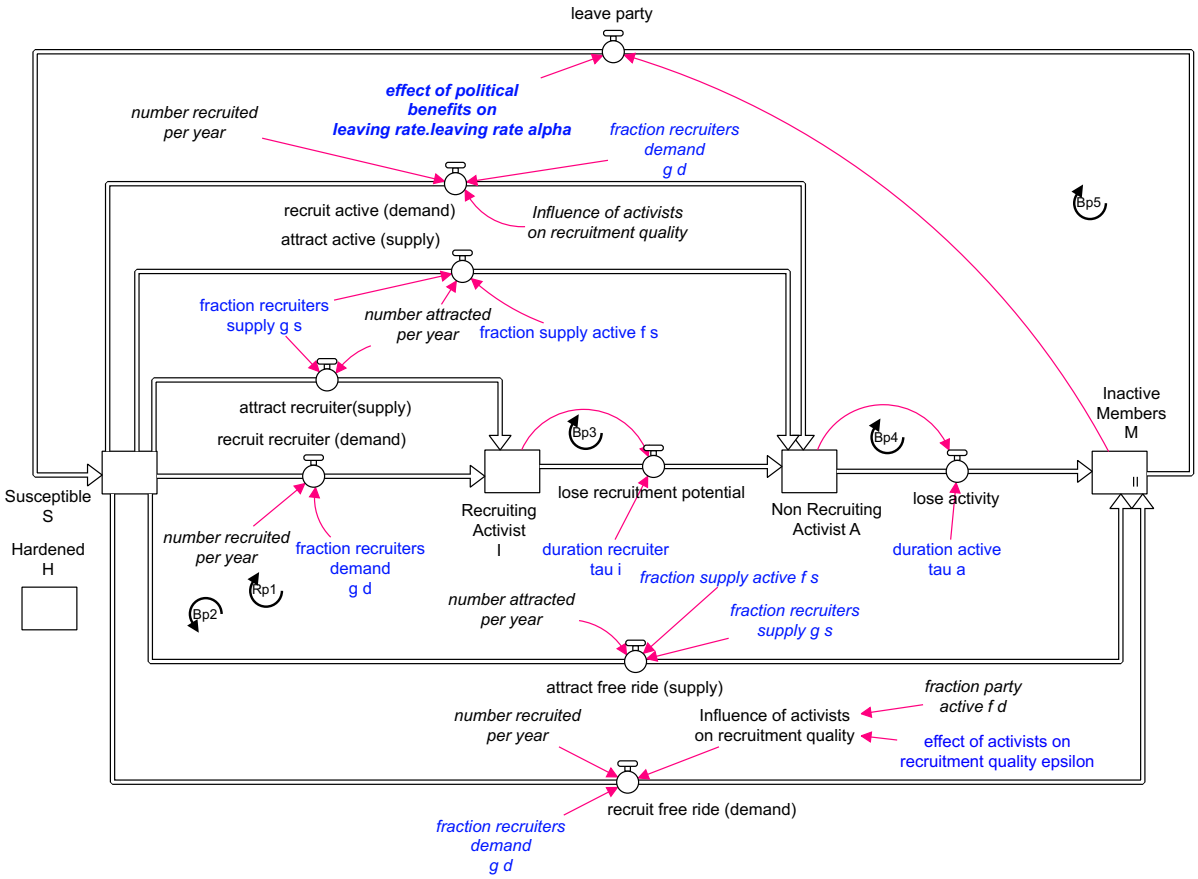

Figure 5: The population module for the Supply and Demand model of Political Party Growth.

The Political Legitimacy module contains the single stock that represents the soft variable political legitimacy L, Figure 6[5]. We have chosen to limit its scale, with a party having a maximum legitimacy L_{max} corresponding to the situation where every voter believes that the party is acceptable. The limited scale is achieved using a goal-seeking pattern pioneered by Levine (2000) and Levine and Doyle (2002), and developed by Hayward et al. (2014). Political legitimacy is scaled by its possible maximum, indicated by an overbar, $\bar{L} = L/L_{max}$, to provide output from the module. Thus, the effect of political legitimacy has a unitary scale that hides its units, separating its potential measures from its use in the full model (Hayward et al., 2014). The input on the inflow is determined by activists and the party size. The fraction free-riding influences the input on the outflow.

[5] We use the same name for both the module and stock as both represent the concept of political legitimacy; the module as a sub-model, and the stock as a value. The same convention is used for personal political benefits.

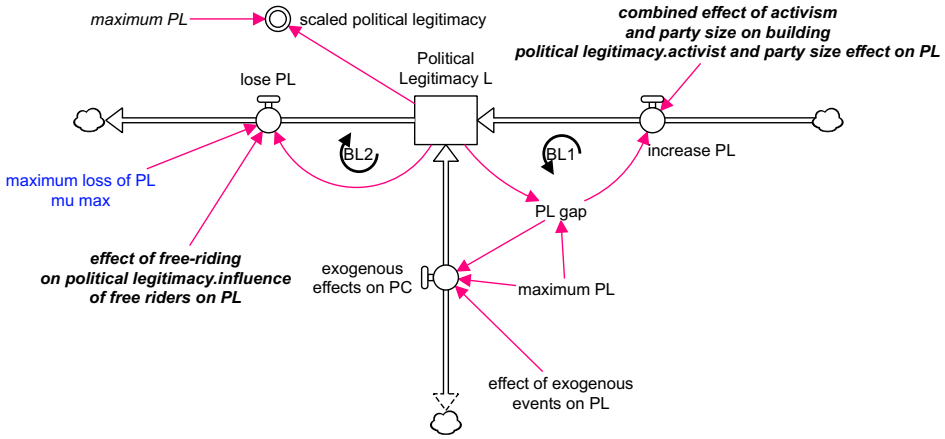

Figure 6: Political legitimacy module.

Personal Political Benefits B is a single stock adjusted according to a target, Political Benefit Target, Figure 7. This target represents the membership benefits set by the party leaders. Its value is set exogenously in this model. We restrict this target to a unitary scale to ensure the stock is also unitary and can be compared with political legitimacy. The adjustment time represents the delay between adjusting benefits and its effect on existing and potential party members. The stock is output.

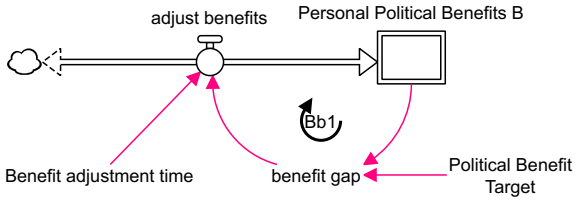

Figure 7: Personal political benefits module.

The population module has three inputs: the demand and supply sectors (Figure 8) and the leaving rate. The recruitment potential is now enhanced with the influence of the attractiveness of the party and the political legitimacy demanded by the party, *enhanced recruitment potential* $= C_p + r_e p_a \tau_i d_M(L)$. Here, p_a represents political attractiveness and $d_M(L)$ the demand effort of the party, where $d_M(L) = e_{pl}(\bar{L}_T - \bar{L})$ if legitimacy is below the target $\bar{L}_T$, otherwise it is zero. Likewise, supply is also influenced by party attractiveness, *number attracted per year* = $a_p p_a S/O$, where $O = S + P$ is the total population open to party membership. The parameters, a_p, r_e, e_{pl} govern the response of supply and demand to political attractiveness and legitimacy. The full details of parameter names, the equations, and how they are contained in the modules, Figure 4, are given in Appendix 2.

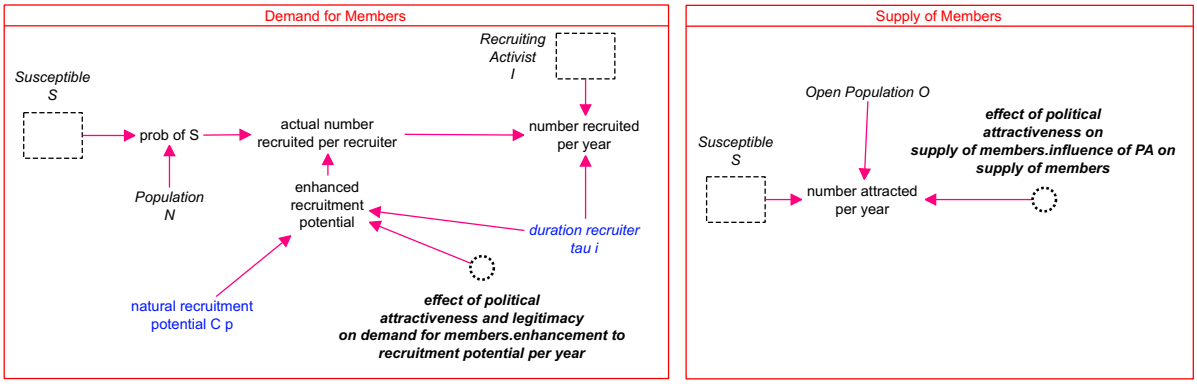

Figure 8: Demand and supply mechanisms with module inputs contained in the Population module.

The leaving rate α is the reciprocal of the *average* duration of party membership τ_p. This duration lies between a minimum and maximum value, following an S-shaped response function: $\tau_p = \tau_{min} + (\tau_{max} - \tau_{min})(1 - e^{-nB})/[1 + e^{-nB}(e^{nB_h} - 2)]$, where n is the sensitivity and $B_h$is the value of benefits that gives a duration halfway between the minimum and maximum. We chose this form of response function as it is largely linear and symmetric but smoothed near the two extremes, in contrast to the more usual ones of Holling (1965), which are generally skewed. We call this the *Exponential Holling function.*

Linking Modules

We use modules to contain the effects of political legitimacy and personal political benefits on the population and the effects of the population on political legitimacy. These modules are indicated by name only in Figure 4; we note that the hiding of converters used to combine effects in modules enables clearer presentation of the main feedback loops.

A party is defined as attractive if it has both political legitimacy and offers personal political benefits. Thus, we define political attractiveness as the product of legitimacy (scaled) and benefits, constructed in the module of the same name, $p_a = \bar{L}B$. This definition is the "and" combination of soft variables defined by Hayward et al. (2014). We follow their convention that the output of soft variables is always dimensionless and on a unitary scale, enabling the logic combinations of such variables as proposed by Nuthmann (1994) and McLucas (2003), based on the work of Anderson (1981).

Although the population variables are not on unitary scales, their effect on any other variables requires them to divided by the total population size so that the model can scale according to different size populations. Thus, for example, the same model will work on constituent regions of a country with the same parameter values as a model of the whole country. The scaled population variables, indicated by an overbar, are unitary, but their values are too small to provide a sufficient effect in a model. We chose an exponential Holling function for the response of political legitimacy to activist numbers to magnify the low activists faction $\bar{A}_T$, while keeping it on the correct scale, *effect of activists on building political legitimacy* $\Omega(\bar{A}_T) = \left(1 - e^{-c\bar{A}_T}\right)/\left[1 + e^{-c\bar{A}_T}\left(e^{c\bar{A}_h} - 2\right)\right]$, facilitated by parameters $c, \bar{A}_h$. This functional form is approximately linear, except near the limits of the scale, where it is S-shaped and smoothed.

If a political party is too small, then its size will have no influence on political legitimacy. Also, once the party reaches a sufficiently large value, it will not build legitimacy any faster. Thus, there are minimum and maximum party membership size thresholds for the response of

legitimacy. We achieve a smoothed version of this response by using a power type Holling function, *effect of activists on building political legitimacy* $\Omega(\bar{P}) = (\bar{P}^n)/[\bar{P}^n + \bar{P}_h^n]$, facilitated by specific values of n and $\bar{P}_h^n$, see appendix 2. This function represents the fuzzy minimum and maximum of Sterman (2000) without using graphical converters.

Political legitimacy is either built by activists, party size, or both, with one effect enhancing the other. Following Hayward et al. (2014) and Anderson (1981), we model this with the "or" logical connective $\Omega(\bar{A}_T, \bar{P}) = \theta_a\Omega(\bar{A}_T) + \theta_p\Omega(\bar{P}) - \theta_a\Omega(\bar{A}_T)\theta_p\Omega(\bar{P})$, thus, retaining the unitary scale. We set $\theta_p = 1 - \theta_a$ so that we can adjust the relative effects of the two population variables.

We determine the level of free-riding by the fraction of inactive members in the party. This fraction has unitary scale values that are reasonably large. Thus, no response function is needed to magnify it. We use a simple power law relationship to govern the loss of political legitimacy over time – the more free-riding, the more its adverse effect on legitimacy, $\mu_{max}(M/P)^{\nu}$. The power adjusts the shape of the response and μ_{max} is the maximum loss rate of legitimacy.

4 Results

Calibration Strategy

The Supply and Demand model of Party Political Growth has a parameter set that is too large to be obtained by optimisation from the available data. Although party membership data is quantitative, political legitimacy and personal political benefits can only be estimated qualitatively from known political events at the time. Thus, any values used for these variables in the model are subject to a degree of uncertainty. Therefore, we confine the optimised parameters to those associated with the epidemiological (demand) mechanism, as these have a high degree of sensitivity. As these parameters are already present in the Limited Activist Model, we can start our calibration by using the optimisation of Jeffs et al. (2015), and then slowly introduce the new features of the Supply and Demand model.

For the benefit of readers who may be unfamiliar with the calibration of models that incorporate soft variables, a calibration strategy is provided below:

1. Obtain a calibration for demand alone by switching off supply, setting political legitimacy to zero and keeping personal political benefits constant against time.
2. Introduce the influence of the population variables on political legitimacy so that it matches the general shape indicated by known political events relating to the party's popularity. The relative effects of party size, activists and free-riders are adjusted to fit the historical narrative.
3. Set the targets for personal political benefits and the political legitimacy demanded by reference to the historical narrative.
4. Slowly introduce the effects of the two soft variables on supply and demand in proportion to what is known from the historical narrative and recalibrate the epidemiological parameters, including those influencing the leaving rate.
5. Check the shape of political legitimacy, as in 2 above, and, if necessary, readjust its input parameters and recalibrate.
6. Once political legitimacy is correct without needing more re-calibration, increase the effects of the two soft variables on the population and follow 5 and 6 again.

The calibration strategy ceases when the graphs of key variables provide a convincing explanation for the growth of the party in its historical context. The variables that are deemed key will become apparent in the following results.

UK Labour Party 1947–1961

The Labour Party's post-war strategy of turning every voter into a member ceased in 1950 as the party had achieved a healthy and active party membership (Jefferys, 2007). Thus, we set *target political legitimacy* to a high number of 0.8 up to 1950 then set it zero until 1960 when the party needed to start recruiting again to face an election. The party lost power in 1951 and had internal divisions for the remainder of the 1950s (Jefferys, 2007). We represent these facts as a drop in personal political benefits as intra-party disputes often lead to people not renewing their membership.

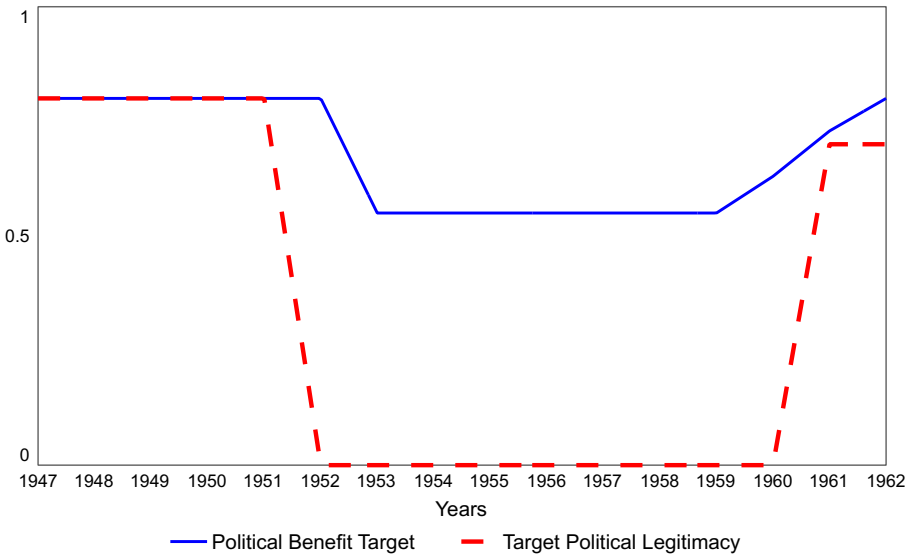

Figure 9: Targets for political legitimacy and personal political benefits, representing exogenous decisions and effects, UK Labour Party, 1947-1961

The 1945 Labour government was the first majority government for the party. Not only had it obtained power, it had also replaced the Liberal Party as the natural opposition to the Conservatives. Nevertheless, it had no proven track record in power; thus, we set the initial political legitimacy to 0.4 as there was clearly still much potential for this parameter to increase. With a growing party membership and rising trust in government, we expect Labour's political legitimacy to increase substantially. We anticipate it would only fall moderately when the party is out of power, as the third party, the Liberals, had collapsed, leaving Labour as the only alternative government option to the Conservatives.

We obtained an excellent fit to the membership data, with the expected rise and fall in political legitimacy, Figure 10. A good fit could only be achieved with a small amount of supply growth, Figure 11, which conforms with the historical narrative, as Labour's growth was known to be mainly by deliberate personal recruitment (Jefferys, 2007; Whiteley and Seyd, 2002)[6]. According to the model, demand fell below supply by 1952, and the party entered a slow decline as supply alone was insufficient to counter the losses. The reduction in personal political benefits magnified the disparity between supply and losses. The party needed a level of demand growth to maintain party numbers, but it is possible the party was too distracted to

[6] Following Jeffs et al. (2015), no attempt was made to fit the 1951 membership value, for the same reasons stated earlier.

be that concerned over these losses. Political parties do not always regard high membership as desirable (Whiteley and Seyd, 2002).

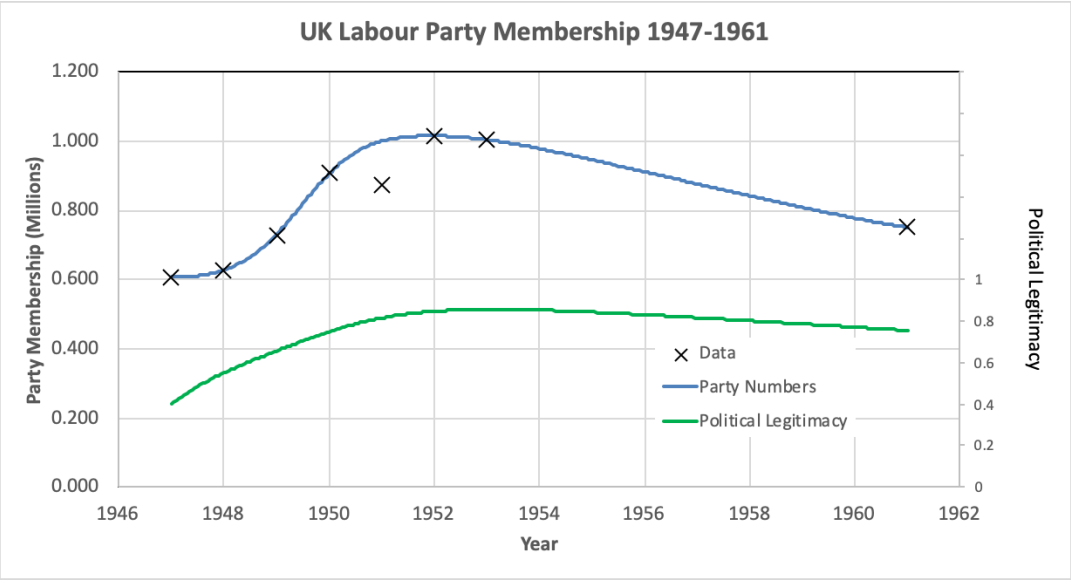

Figure 10: Supply and Demand Model applied to the UK Labour Party 1947–1961. Parameter values are given in Appendix 2.

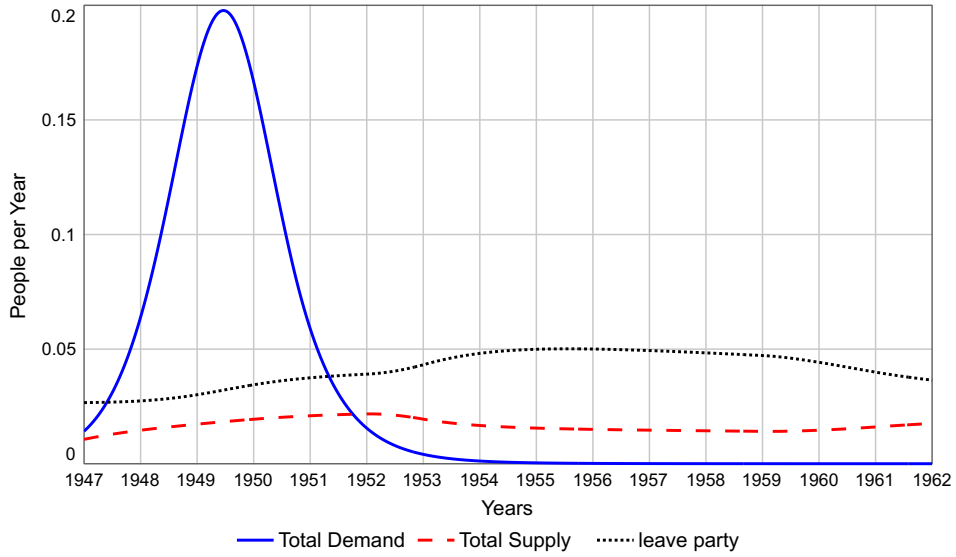

Figure 11: Supply, demand and leaving rates, UK Labour Party 1947–1961.

Historical evidence suggests that activists played a significant role in building the party's political legitimacy through their influence in the union movement, the workplace, and door-to-door recruitment (Jefferys, 2007). We chose a calibration where the activists' influence matched the influence of the party size, Figure 12. We could obtain data fit without the influence of the party size but not without the influence of the activists. It is possible that, at that time, the electorate had become less impressed with party size as a mark of legitimacy and needed more persuasion from individuals. The model indicates that activists also played an important role in reducing free-riding among new members during their recruitment phase, which also helped improve legitimacy, Figure 12.

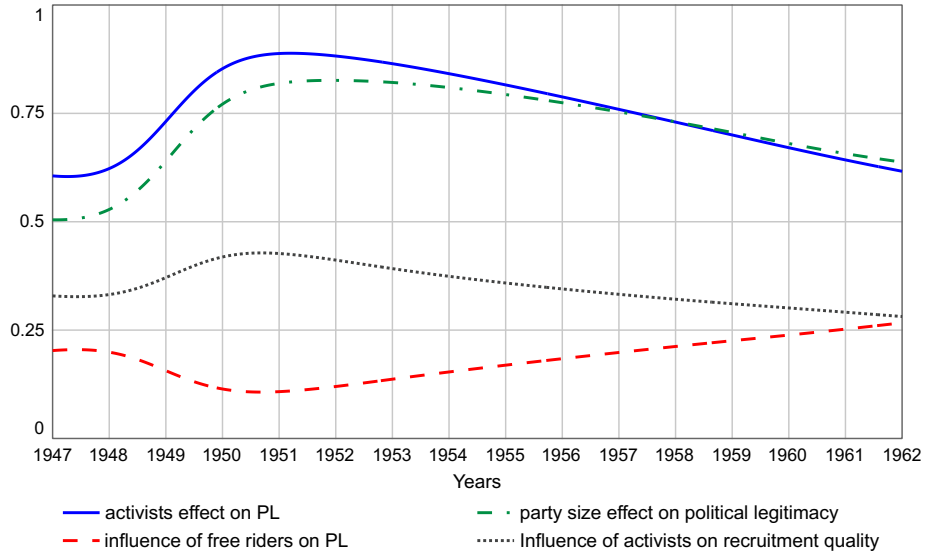

Figure 12: Effects of activists, free-riders and party size; UK Labour Party 1947-1961.

We tested the mechanism for combining the party size and activist influences on political legitimacy, Figure 13. In 1951, the two effects were 0.41 and 0.44, respectively. The combined effect was 0.67, less than the sum of the two, following the logical mechanism that keeps the scale unitary. Thus, the one effect can enhance the other, but the enhancement is less pronounced the larger the effects become. The party membership starts halfway between the minimum and maximum thresholds, the lowest curve in Figure 13, which is reasonable given the party's increase in size from 1945-47. At its peak, the party membership reaches the maximum threshold, indicating that no further increase in size would have helped enhance legitimacy. We believe this is justified as although the opposition Conservative party had a larger membership, this did not translate into higher legitimacy, as both parties were evenly matched in the popular vote (Audickas et al., 2019; "UK Political Info," 2019).

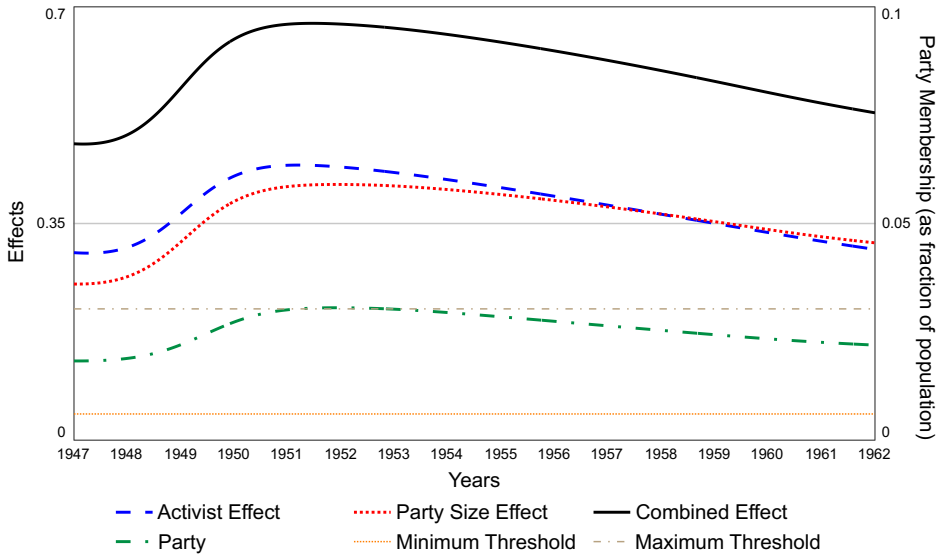

Figure 13: Influences on political legitimacy, UK Labour Party 1947-1961.

For the political party to be attractive, it needs both legitimacy and benefits for members. This simulation suggests that once Labour had achieved a reasonable level of legitimacy, the variation in members' benefits was the primary factor determining attractiveness. Whereas it

is important for new and recovering parties to work to increase legitimacy, this model indicates that for established parties, dealing with member benefits will have more effect in building membership. This strategy has been adopted recently by both the Scottish National Party (Jeffs et al., 2015) and the UK Labour Party (Whiteley, Poletti, Webb, and Bale, 2019), who have substantially increased their membership with offers of participation in meaningful political change.

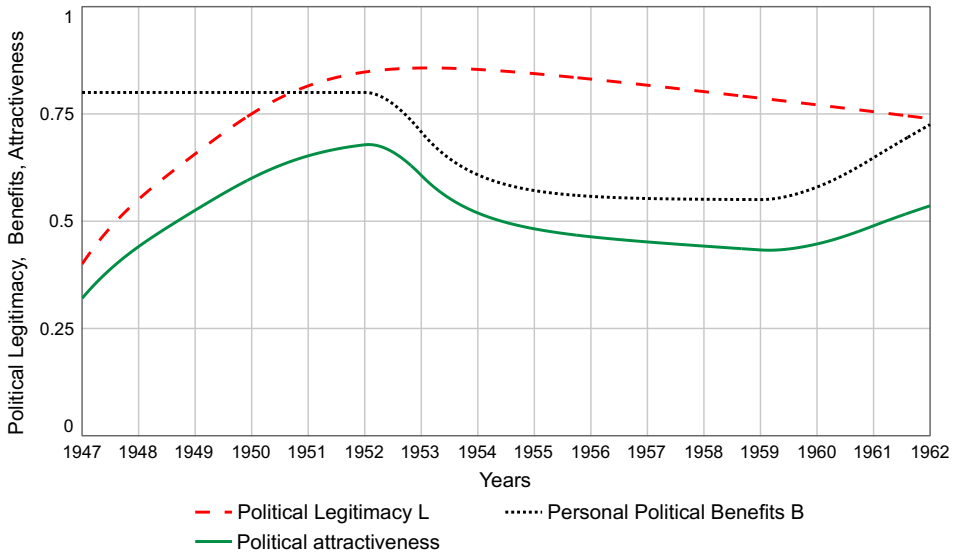

Figure 14: The effect of political legitimacy and personal political benefits on political attractiveness, UK Labour Party 1947-1961.

UK Labour Party 1993 – 2009

The Labour Party's strategy of raising its legitimacy ceased as soon as its target of winning the 1997 general election was achieved (Whiteley and Seyd, 2002). We represent this change of strategy by the drop in the political legitimacy target from that year, Figure 15. Likewise, we set a simultaneous reduction in benefits to members, as the party's measures to engage with the opinions of members also ceased due in part to the party turning its attention from campaigning to exercising power. We placed a further reduction in benefits in 2003, the year of the Iraq war when there were many temporary membership resignations. The momentary rise in benefits in the following year represents the re-joining of those members who left. We first simulate the period from 1993-2005 using a single optimisation, deferring discussion of the post-2005 period to the end of our analysis.

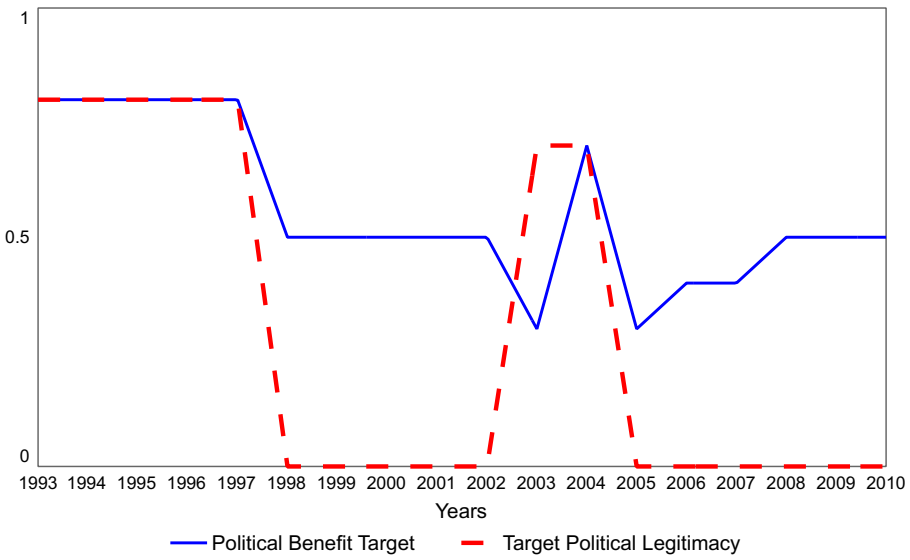

Figure 15: Targets for political legitimacy and personal political benefits, representing exogenous decisions and effects, UK Labour Party, 1993-2009

We set the initial political legitimacy to 0.4, representing the loss of electoral popularity of a party that had been out of government for fourteen years. We do not expect legitimacy to rise as high as in the 1950s Labour scenario, as the party was in a position to win power with a smaller share of the popular vote than earlier due to the rising popularity of the Liberal Democrats and Nationalists splitting of the constituency votes. Thus, we allowed legitimacy to rise to a high value of around 0.7, below the 1950s' maximum, while keeping it above the 1993 value of 0.4 in 2005 as Labour were still more popular than the opposition. This scenario is reflected in our simulation, Figure 16, where we obtained an excellent fit to the membership data from 1993–2005. This data fit represents a significant improvement over the Limited Activist model, Figure 3, where the post-election fall in membership has been replicated.

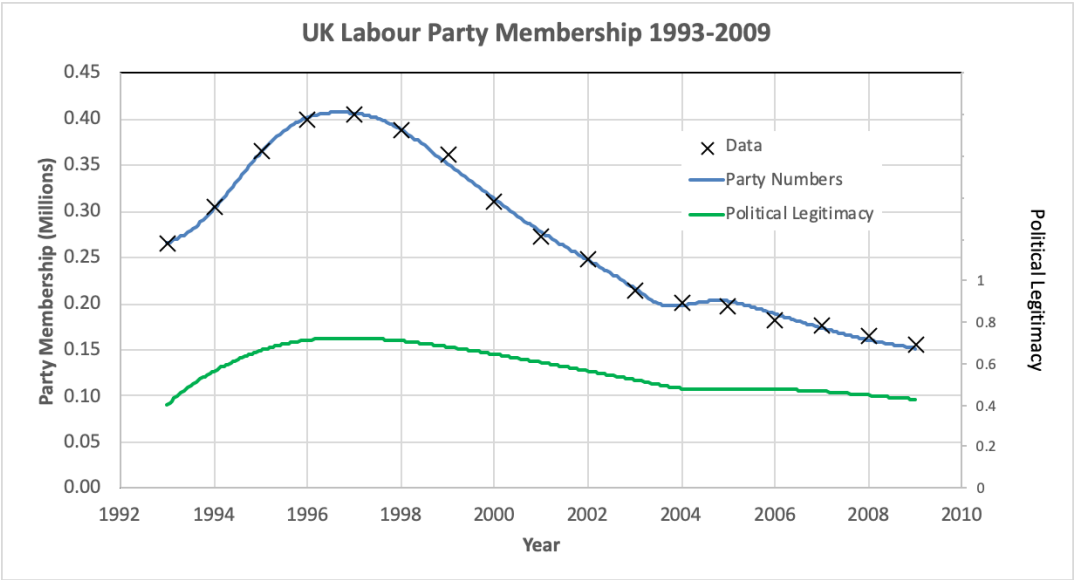

Figure 16: Supply and Demand Model applied to the UK Labour Party 1993–2009. Parameter values are given in Appendix 2.

To obtain a good data fit, we required a much higher proportion of supply over demand compared with the 1940s campaign, Figure 17, which is also suggested by the party's use of focus groups and publicity methods (Whiteley and Seyd, 2002). Thus, the steep decline is partly explained by a fall in demand and the reduction in supply due to the lower personal political benefits, Figure 17. The lower benefits also increased the leaving rate, giving the third cause of rapid membership decline. The party's promise of electoral victory had been achieved, and there were no other incentives for people to either join or remain in the party, leaving membership to the most committed. This simulation suggests that the party had mainly recruited inactive members, Figure 18, and these left in increasingly large numbers following the election victory. The smaller role of activists in the 1990s campaign, compared with the 1940s, is also reflected in their reduced role in building political legitimacy, Figure 19. Instead, legitimacy was built mainly through the increasing size of the party, frequently advertised through the country's media.

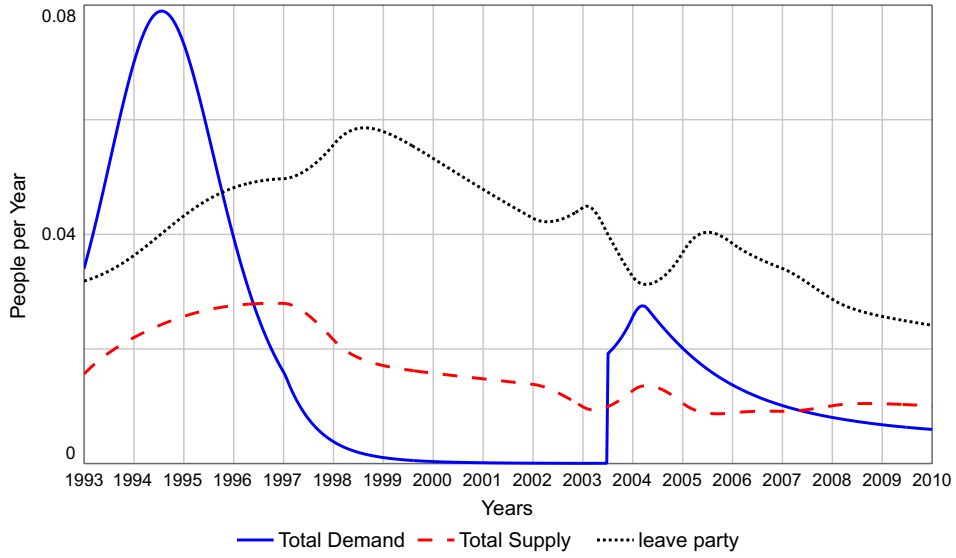

Figure 17: Supply, demand and leaving rates, UK Labour Party 1993–2009.

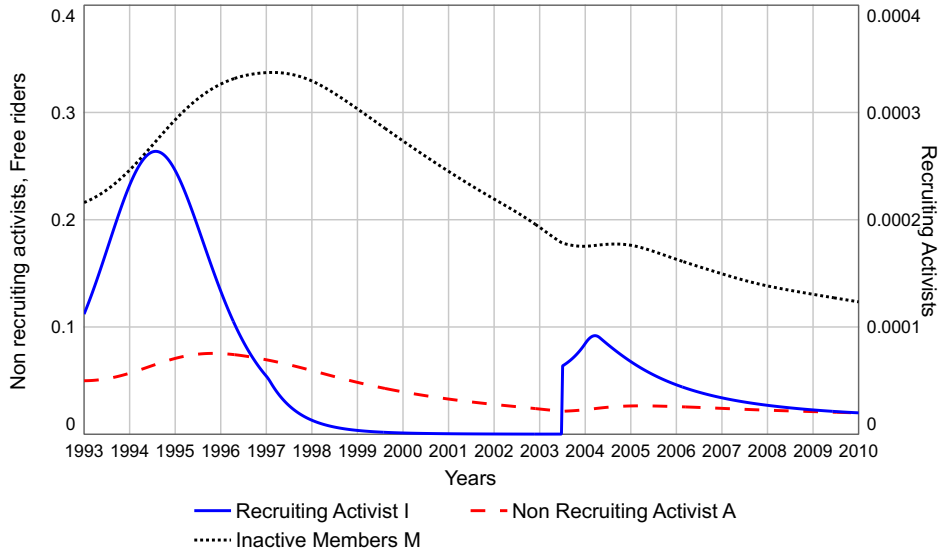

Figure 18: Party membership types, UK Labour Party 1993–2009.

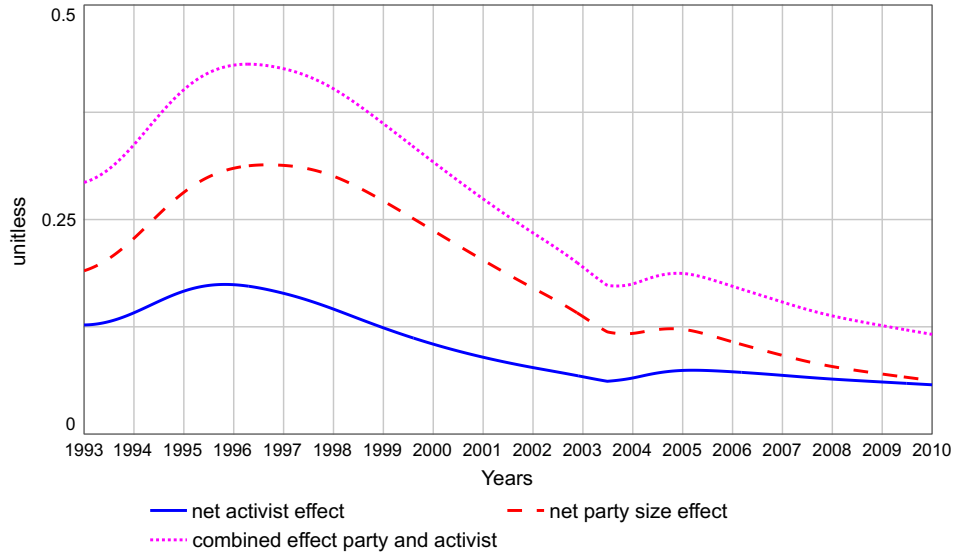

Figure 19: Influences on political legitimacy, UK Labour Party 1993–2009.

Replicating the much smaller decline in party membership after 2005 was not possible with the 1993–2005 optimisation. Instead, we conjecture that the party launched a brief recruitment campaign in 2003–2004 to help secure the 2005 election and undo the damage to the party from the Iraq war, Figure 15. To restart the demand mechanism, we manually allowed some activists to become recruiters and then recalibrated the epidemiological parameters of the model. This strategy gave a good fit to the data up to 2009, Figure 16, especially when we added a small rise in membership benefits. We could not obtain a good data fit by varying benefits alone, suggesting that some form of demand-led recruitment must have occurred at that time. Although party decline was arrested, political legitimacy did not recover, falling below the 1993 value by 2009. The Labour Party lost the election in 2010, indicating that its legitimacy had fallen to values not seen since it was last out of government, as supported by the model simulation. The party's recruitment campaign was insufficient to raise political legitimacy as it was much weaker than the 1993–97 one, Figures 17 and 18.

5 Conclusion

In this paper, we have extended an existing model of political party growth – the Limited Activist model – and applied it to two test data sets. The new model – the Supply and Demand model – included two soft variables representing political legitimacy and personal political benefits. These variables enabled us to add recruitment by supply to the model and improve the demand form of recruitment in the Limited Activists model by incorporating target legitimacy set by party leaders.

Comparing the data fits for the two models, the Supply and Demand model provided a significantly improved data fit for the one data set that had previously given problems. It was clear that demand-led recruitment was insufficient to explain party growth and that some level of supply always exists even when recruitment campaigns have ended. Additionally, the new model provided a richer explanation of behaviour over the previous one, explaining growth and decline using party policies on desired legitimacy and benefits to members.

The new model demonstrates the need to include relevant soft variables in the modelling process. Although both soft concepts, political legitimacy and personal political benefits, are hard to measure quantitatively, the new model demonstrates how informal estimates of target levels of these variables can produce a realistic narrative of historical events and assist in

model calibration. The use of limited scales for the soft variables and the associated logical algebra of Hayward et al. (2014) used to combine these variables helped furnish a framework to construct the soft variables and their connections.

This paper also demonstrated a way of including soft variables in a model by using a modular structure. This structure separates the *use* of a soft variable in the model from its *meaning* and *possible measures* by hiding the units in the module and limiting communications between the modules to clear inputs and outputs. The influence of the soft variables on the population variables, and vice versa, were also contained in modules, enabling the module map to show the feedback structure between the variables. We believe the use of modules provides a clearer presentation of a large model. This paper also developed several bespoke response functions to express the effect of population variables on the soft variables without violating scales and unrealistic numerical effects that could place artificial boundaries on the model. Thus, we were able to produce a calibration strategy combining optimisation with iteration that successfully replicated data and informal expectations.

The primary contribution of this paper is to present a model of political party growth that possesses sufficient explanatory power to assist party leaders and activists in understanding past behaviour and to inform future strategies. To further pursue the goals of our ongoing research, we intend to apply the model to a wider range of political party data and movements.

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Appendix 1 Limited Activist Model – Equations and Calibration

The equations for the Limited Activist Model, Figure 1, reduce to the differential equations (Jeffs et al., 2015):

$$\begin{aligned}
\frac{dS}{dt} &= -\frac{C_p}{\tau_i N} SI + \alpha M \\
\frac{dI}{dt} &= g\frac{C_p}{\tau_i N} SI - \frac{I}{\tau_i} \\
\frac{dA}{dt} &= f(1-g)\frac{C_p}{\tau_i N} SI + \frac{I}{\tau_i} - \frac{A}{\tau_a} \\
\frac{dM}{dt} &= (1-f)(1-g)\frac{C_p}{\tau_i N} SI + \frac{A}{\tau_a} - \alpha M
\end{aligned}$$

where I are recruiting activists, A are non-recruiting activists, M are inactive members also called free-riders, H are hardened – that is not open to joining the party, $f = f(A_T) = \frac{A_T}{N}$, total activists $A_T = I + A$, party membership $P = A_T + M$, total open to the party $O = S + P$, total population $N = O + H$.

Parameter values are reproduced from (Jeffs et al., 2015) except for the leaving rate for labour 1947–1961 which we obtained by optimisation, closely matching their original value.

*Table 1: Data fit of Limited Activist model to Labour Party membership data 1947–1961. Parameters optimised indicated by **

Parameter	Value
Initial Population $\boldsymbol{N_0}$ (Electorate)	33.24 million
Initial Open $\boldsymbol{O_0}$ (Voted for party)	11.995 million
Initial Party $\boldsymbol{P_0}$	608,000
Initial Activists $\boldsymbol{A_{T0} = A_0 + I_0}$	200,000
Duration Active $\boldsymbol{\tau_a}$	10
Leaving Rate $\boldsymbol{\alpha}$ *	0.05289
Fraction Recruiters $\boldsymbol{g}$	0.5
Recruitment Potential $\boldsymbol{C_p}$ *	5.9503
Duration Recruiter $\boldsymbol{\tau_i}$ *	0.0144
Initial Recruiters $\boldsymbol{I}$ *	139

*Table 2: Data fit of Limited Activist model to Labour Party membership data 1993–2005. Parameters optimised indicated by **

Parameter	Value
Initial Population $\boldsymbol{N_0}$	43.25 million
Initial Open $\boldsymbol{O_0}$	11.56 million
Initial Party $\boldsymbol{P_0}$	266,000
Initial Activists $\boldsymbol{A_{T0} = A_0 + I_0}$	50,000
Duration Active $\boldsymbol{\tau_a}$	10
Leaving Rate $\boldsymbol{\alpha}$	0.15
Fraction Recruiters $\boldsymbol{g}$	0.2

Recruitment Potential $\boldsymbol{C_p}$ *	19.2712
Duration Recruiter $\boldsymbol{\tau_i}$ *	0.00945
Initial Recruiters $\boldsymbol{I}$ *	101

Appendix 2 Supply and Demand Model – Equations and Calibration

The model equations are given by module. The parameters are named in the calibration tables.

Population Module

$$\begin{aligned}
\frac{dS}{dt} &= -\frac{C_p(L)}{\tau_i N} SI - F_{pa,s}\frac{S}{O} + \alpha(B)M \\
\frac{dI}{dt} &= g_d \frac{C_p(L)}{\tau_i N} SI + g_s F_{pa,s}\frac{S}{O} - \frac{I}{\tau_i} \\
\frac{dA}{dt} &= f_d^{\epsilon}(1-g_d)\frac{C_p(L)}{\tau_i N} SI + f_s(1-g_s)F_{pa,s}\frac{S}{O} + \frac{I}{\tau_i} - \frac{A}{\tau_a} \\
\frac{dM}{dt} &= (1-f_d^{\epsilon})(1-g_d)\frac{C_p(L)}{\tau_i N} SI + (1-f_s)(1-g_s)F_{pa,s}\frac{S}{O} + \frac{A}{\tau_a} - \alpha(B)M
\end{aligned}$$

where

$$\begin{aligned}
C_p(L) &= C_p + \tau_i F_{pa,d} \\
f_d &= f_d(A_T) = \frac{A_T}{N}
\end{aligned}$$

and I are recruiting activists, A are non-recruiting activists, M are inactive members also called free-riders, H are hardened – that is, they are not open to joining the party, total activists $A_T = I + A$, party membership $P = A_T + M$, total open to the party $O = S + P$, total population $N = O + H$.

Inputs: $F_{pa,d}$, $F_{pa,s}$,
Outputs: $\bar{A}_T = A_T/N$, $\bar{P} = P/N$, $\widetilde{M} = M/P$

Effect of Political Attractiveness on Supply of Members Module

$$F_{pa,s} = a_p p_a$$

Effect of political attractiveness and legitimacy on demand for members

$$F_{pa,d} = r_e p_a d_m(\bar{L})$$

Political Attractiveness

$$p_a = B\bar{L}$$

Demand Effort of Party

$$d_m(\bar{L}) = e_{pl}(\bar{L}_T(t) - \bar{L})$$

where $\bar{L}_T(t)$ is the target political legitimacy set by the party.

Political Legitimacy Module

$$\frac{dL}{dt} = \Omega(\bar{A}_T, \bar{P})(L_m - L) - \mu(\widetilde{M})L$$

where $L_m$is the maximum value of political legitimacy.

Inputs: $\Omega(\bar{A}_T, \bar{P}),\ \mu(\widetilde{M})$
Output: $\bar{A}_T = L/L_m$

Personal Political Benefits Module

$$\frac{dB}{dt} = \frac{1}{\tau_b}(B_T(t) - B)$$

where $B_T(t)$ is the target personal political benefits, either set by the party or determined by exogenous events.

Output: B

$B_T(t)$ is set within a unitary scale, thus B is unitary without the need for further scaling.

Effect of Political Benefits on Leaving Rate Module

$$\alpha(B)^{-1} = \tau_p = \tau_{min} + \frac{(\tau_{max} - \tau_{min})(1 - e^{-nB})}{1 + e^{-nB}(e^{nB_h} - 2)}$$

The second term is an exponential form of the Holling function to mimic a smoothed and symmetric S-shaped response, where *n* determines the length of the straight section and B_h the degree of symmetry.

Effect of Free-riding on Political Legitimacy

$$\mu(\widetilde{M}) = \mu_m \widetilde{M}^{\nu}$$

Combined Effect of Activism and Party Size on Building Political Legitimacy

$$\Omega(\bar{A}_T, \bar{P}) = \theta\left[\Omega_a(\bar{A}_T) + \Omega_p(\bar{P}) - \Omega_a(\bar{A}_T)\Omega_p(\bar{P})\right]$$

The combination follows the logical "or" pattern so that one effect adds to the other, without the unitary scale being violated. θ determines the maximum combined effect.

Effect of Activists Building Political Legitimacy

$$\Omega_a(\bar{A}_T) = \frac{\theta_a\left(1 - e^{-c\bar{A}_T}\right)}{1 + e^{-c\bar{A}_T}\left(e^{c\bar{A}_h} - 2\right)}$$

The response is an exponential Holling response functions (see above). θ_a on a scale 0 to 1 determines the maximum effect.

Effect of Party Size on Building Political Legitimacy

$$\Omega_p(\bar{P}) = \frac{\theta_p \bar{P}^{\lambda}}{\bar{P}^{\lambda} + \bar{P}_h^{\lambda}}$$

Where

$$\lambda = 2\frac{\bar{P}_{max} + \bar{P}_{min}}{\bar{P}_{max} - \bar{P}_{min}}$$
$$\bar{P}_h^{\lambda} = \frac{1}{2}(\bar{P}_{max} + \bar{P}_{min})$$

This expression is a power law Holling function where $\bar{P}_h^{\lambda}$ and λ have been chosen so that the mid-point of the response has the same gradient as the straight line between $\bar{P}_{min}$and $\bar{P}_{max}$. Thus, it is a form of fuzzy minimum and maximum. θ_p on a scale 0 to 1 determines the maximum effect.

*Table 3: Data fit of Supply and Demand model to Labour Party membership data 1947–1961. Parameters optimised indicated by **

Parameter	**Value**
Initial Population $\boldsymbol{N_0}$	33.24 million
Initial Open $\boldsymbol{O_0}$	11.995 million
Initial Party $\boldsymbol{P_0}$	608,000
Initial Activists $\boldsymbol{A_{T0} = A_0 + I_0}$	200,000
Initial Recruiters $\boldsymbol{I}$ *	134
Initial Political Legitimacy	0.4
Natural Recruitment Potential $\boldsymbol{C_p}$ *	5.8951
Potential Number Attracted per Year $\boldsymbol{a_p}$	0.035
Duration Recruiter $\boldsymbol{\tau_i}$ *	0.0195
Duration Active $\boldsymbol{\tau_a}$ *	10.485
Fraction Recruiters Demand $\boldsymbol{g_d}$	0.5
Fraction Recruiters Supply $\boldsymbol{g_s}$	0
Half Value Activists Fraction Building $\boldsymbol{\bar{A}_h}$	0.00461
Sensitivity of Activists $\boldsymbol{c}$	200
Maximum Party Fraction for Legitimacy (threshold) $\boldsymbol{P_{max}}$	0.0303
Minimum Party Fraction for Legitimacy (threshold) $\boldsymbol{P_{min}}$	0.0060
Effect of Party Size and Activists on Building PL $\boldsymbol{\theta}$	0.88
Effect of Activists on Building PL $\boldsymbol{\theta_a}$	0.5
Maximum Loss of PL $\boldsymbol{\mu_m}$	0.7
Effect of Free Riders on PL Depletion $\boldsymbol{v}$	4
Fraction Supply Active $\boldsymbol{f_s}$	0.4
Effect of Activists on Recruitment Quality $\boldsymbol{\epsilon}$	1
Effect of Attractiveness on Recruitment Potential $\boldsymbol{r_e}$	5
Demand Effort Exerted by Party to Raise Political Legitimacy $\boldsymbol{e_{pl}}$	10
Minimum Time in Party $\boldsymbol{\tau_{min}}$	0.1
Maximum Time in Party $\boldsymbol{\tau_{max}}$ *	21.83
Sensitivity Pa on Leaving Rate $\boldsymbol{n}$ *	2.05
Half Value Duration in Party $\boldsymbol{B_h}$	0.5

*Table 4: Data fit of Supply and Demand model to Labour Party membership data 1993–2009. Parameters optimised indicated by **

Parameter	Value
Initial Population N_0	43.25 million
Initial Open O_0	11.56 million
Initial Party P_0	266,000
Initial Activists $A_{T0} = A_0 + I_0$	50,000 **
Initial Recruiters I *	112
Initial Political Legitimacy	0.4
Natural Recruitment Potential C_p *	18.9078
Potential Number Attracted per Year a_p	0.05
Duration Recruiter τ_i *	0.0167
Duration Active τ_a *	2.8
Fraction Recruiters Demand g_d	0.2
Fraction Recruiters Supply g_s	0
Half Value Activists Fraction Building $\bar{A}_h$	0.003ß
Sensitivity of Activists c	127
Maximum Party Fraction for Legitimacy (threshold) P_{max}	0.0139
Minimum Party Fraction for Legitimacy (threshold) P_{min}	0.0017
Effect of Party Size and Activists on Building PL θ	2
Effect of Activists on Building PL θ_a	0.5
Maximum Loss of PL μ_m	0.7
Effect of Free Riders on PL Depletion v	4
Fraction Supply Active f_s	0.4
Effect of Activists on Recruitment Quality ϵ	1
Effect of Attractiveness on Recruitment Potential r_e	25
Demand Effort Exerted by Party to Raise Political Legitimacy e_{pl} ***	10 1993–2003 15.2 2003–2009
Minimum Time in Party τ_{min}	1
Maximum Time in Party τ_{max} *	9.241
Sensitivity Pa On Leaving Rate n *	2.099
Half Value Duration in Party B_h	0.5

** We needed to reduce the initial number of activists to obtain a good data fit.
*** The second phase of recruitment had a higher demand effort from 2003.49. 63 non-recruiting activists need to become “recruiting” to start the campaign.