# Constraint-Driven Macroeconomics

## Integrating Modern Monetary Theory with the Theory of Constraints

## A Model For Government and Private Investment with Inflationary Control.

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## Contents

# 1 Abstract

Monetarily sovereign governments, as explained by **Modern Monetary Theory (MMT)**, do not face financial constraints in their own currency; they face *real* constraints: labour, energy, materials, logistics, technology, and time. Eliyahu Goldratt's **Theory of Constraints (ToC)** offers a disciplined method to identify and elevate bottlenecks in complex systems. **Constraint-Driven Macroeconomics (CDM)** fuses MMT's operational clarity about money with ToC's practical method for throughput management. The result is a replicable, data-driven policy framework that (1) identifies economy-limiting constraints, (2) aligns fiscal, regulatory, and credit tools to exploit and elevate those constraints, and (3) uses inflation as the macro signal of capacity stress. We set out concepts, metrics, an institutional design, and an implementation roadmap for the UK, with transferable lessons for other sovereign issuers.

In doing so, this paper makes five specific contributions: (1) it integrates Modern Monetary Theory with the Theory of Constraints into a unified macro-fiscal framework; (2) it defines a Constraint Index (CI) and Inflation Risk Index (IRI) for identifying and ranking bottlenecks; (3) it presents an operational inflation decomposition linked to real constraints; (4) it specifies institutional and governance arrangements for a National Constraint Board and associated dashboards; and (5) it outlines an implementable allocation algorithm and roadmap suitable for empirical testing and policy adoption.

## 2 Executive Summary

- **Problem:** UK macro management prioritises financial ratios (deficits, debt/GDP) and blunt interest-rate tools, while under-managing *real capacity*.
- **Insight:** For a currency-issuing government, money is a policy instrument; capacity is the constraint. Modern Monetary Theory (MMT) is not a policy agenda but a descriptive framework that sets out how sovereign currency systems operate in practice: government spending creates pounds, taxation deletes them, and inflation marks the point at which spending exceeds real capacity. CDM builds on this operational clarity, converting it into a usable, disciplined system of government that identifies, targets, and relieves real-world constraints.
- **Solution:** Apply ToC's five focusing steps to the national economy, funded and coordinated via MMT-consistent fiscal operations.
- **Deliverable:** A standing, real-time governance system that targets constraint relief — not arbitrary budget targets — to maximise sustainable wellbeing without igniting inflation.
- **Outcomes:** Faster growth in real output, stabilised inflation via targeted constraint relief, shorter project lead times, and clearer public accountability through transparent "Constraint Dashboards."

CDM replaces blunt interest-rate reliance with targeted capacity relief anchored in real-resource diagnostics.

## Notation Summary

$P_s$ Price pressure indicator (normalised or z-scored)

$Q_s$ Quantity/throughput pressure indicator

$L_s$ Labour pressure indicator

$D_s$ Dependency/fragility indicator

$\mathrm{CI}_s$ Constraint Identification Index

$\mathrm{IRI}_s$ Inflation Risk Index

$G_s(\Delta S_s)$ Capacity-gain function for sector $s$

$\Delta S_{\text{budget}}$ Required constraint budget

$\tilde{P}_s$ Normalised price indicator for sector $s$ (z-scored or baseline ratio).

$\tilde{Q}_s$ Normalised queue / lead-time indicator for sector $s$.

$\tilde{L}_s$ Normalised labour-tightness indicator (vacancy ratio or wage-acceleration index).

$\tilde{D}_s$ Normalised dependency indicator combining import reliance, SPOF exposure, and strategic criticality.

$w_p, w_q, w_l, w_d$ Policy weights used in CI and IRI (set annually by the National Constraint Board).

$\kappa$ Amplification parameter capturing how dependency risk increases inflation exposure.

# 3 Background and Motivation

## 3.1 The Limits of Financial-Ratio Management

Conventional frameworks treat government finance like a household, elevating nominal limits and ratio targets while ignoring dormant capacity. This misdiagnosis leads to austerity during slack and indiscriminate rate hikes during supply shocks.

## 3.2 Monetary Sovereignty or Modern Monetary Theory (MMT)

MMT clarifies that the UK government creates pounds when it spends and deletes pounds when it taxes. The **ultimate constraint is inflation**, which arises when spending attempts to purchase more real resources than the economy can supply. Therefore, macro management should prioritise **resource mapping and capacity governance**.

## 3.3 Operational Management (ToC)

ToC frames every system as being limited by *one or a few* bottlenecks. Improving non-bottlenecks is wasteful; improving the constraint transforms the system. The ToC cycle — **Identify** $\rightarrow$ **Exploit** $\rightarrow$ **Subordinate** $\rightarrow$ **Elevate** $\rightarrow$ **Repeat** — is a continuous improvement method grounded in real-world flow.

Taken together, these two traditions are complementary but incomplete. MMT clarifies that the binding limits on sovereign spending are real resources and inflation, yet it typically treats those constraints in aggregate form. ToC, by contrast, provides a disciplined method for locating and relieving specific bottlenecks, but is usually applied at the level of firms or projects and is silent on sovereign monetary operations. Constraint-Driven Macroeconomics (CDM) fuses these perspectives: it uses MMT's operational understanding of money to remove artificial financial limits, and ToC's focusing process to identify and elevate the real constraints that matter for national throughput and inflation.

# 4 Definitions and Core Principles

**Notation Conventions.** Throughout this paper, sector-specific indicators carry a subscript $s$ (e.g. $P_s$, $Q_s$, $L_s$, $D_s$). Where uppercase letters refer to growth rates or proportional movements, the corresponding deltas (e.g. $\Delta P_s$) refer to short-term changes. All indices are normalised either through min–max scaling or z-scoring as specified in Section 6.1; weights $\alpha$, $\beta$, $\gamma$, $\delta$ satisfy $\alpha + \beta + \gamma + \delta = 1$ unless stated otherwise. Scalars appear in italic; vectors in bold; time subscripts (e.g. $t$) refer to discrete monthly or quarterly updates.

- **Constraint (macro):** The scarcest real resource or process limiting national throughput at a given time.
- **Throughput (macro):** The flow of socially valuable goods and services per unit time.
- **Inflation (policy signal):** A macro indicator that aggregate demand is pressing against one or more real constraints.
- **Real Constraint Doctrine (AIMS standard):** *The real constraint on spending is resource availability (labour, energy, materials, capacity); inflation is the ultimate constraint and can arise whenever spending exceeds real capacity or when shortages in any essential input occur.*
- **Monetary Operations (Sovereign Currency Issuance).** For a monetarily sovereign government such as the UK, spending creates new pounds as an operational matter: the Treasury instructs the Bank of England to credit the relevant bank accounts, and the new money appears as deposits in the commercial banking system. Taxation removes (deletes) pounds, reducing private sector balances.

  Government bonds (gilts) do *not* finance spending. They are issued after spending has occurred, for the purposes of:

  - providing an interest-bearing savings instrument for the private sector;
  - managing interest rates and financial conditions; and
  - offering a safe asset for pensions, banks, and institutional investors.

  Gilts therefore represent a portfolio choice for the private sector — an exchange of one government liability (bank reserves or deposits created by prior spending) for another (an interest-bearing gilt). They are "debt" only as an accounting classification, not a financing constraint.

  This operational reality is visible in the currency itself. A Bank of England banknote (e.g. a £10 note) carries the promise: *"I promise to pay the bearer on demand the sum of ten pounds."* The note is the asset; the promise is the government's liability. A gilt functions the same way: it is another form of government promise, differing only in maturity and the payment of interest. Holding a gilt instead of a banknote is therefore a choice about the form in which the private sector wishes to save, not a prerequisite for government spending.

  The real limit on sovereign expenditure is not the availability of pounds but the availability of labour, energy, materials, productive capacity, and logistical throughput. Inflation emerges when spending attempts to exceed these real constraints.

**Social Floor vs Constraint Budget.** CDM assumes the existence of a politically determined social floor—pensions, income support, disability and care provision—that is not optimised by the constraint index but taken as a baseline commitment. The CDM machinery then governs the allocation of additional fiscal space to constraint relief. This separation preserves democratic control over the level and design of social provision while ensuring that its macro effects are monitored through the same real-resource lens.

We use tildes (e.g. $\tilde{P}_s$) to denote normalised indicators used for cross-sector comparison, and hats (e.g. $\hat{P}_s$) to denote inflation-risk-adjusted indicators used in the IRI. This ensures that $\mathrm{CI}_s$ and $\mathrm{IRI}_s$ remain conceptually distinct while relying on a common underlying data structure.

# 5 The Constraint-Driven Macroeconomic (CDM) Framework

## 5.1 Conceptual Synthesis

**MMT provides the freedom:** finance no longer binds action for a sovereign issuer.
**ToC provides the discipline:** focus strictly on the binding constraint and align everything to elevate it.

## 5.2 The Five Focusing Steps at National Scale

1. **Identify** the binding constraint(s)
   Use inflation decomposition, capacity utilisation, vacancy-to-unemployment ratios, order backlogs, queue/lead times, import dependence, and price spikes to locate bottlenecks.

2. **Exploit** the constraint
   Remove obvious frictions: permitting delays, rostering inefficiencies, procurement bottlenecks, under-use of existing kit.

3. **Subordinate** everything else
   Align fiscal, regulatory, migration/skills, and credit guidance to support the constraint area; de-prioritise competing non-critical uses of the same resources.

4. **Elevate** the constraint
   Fund additional capacity: training pipelines, equipment, grid nodes, housing for key workers, targeted R&D, or short-term imports of capacity.

5. **Repeat**
   Constraints move. Re-run the loop continuously, guided by live data.

## 6 Metrics and Tooling

### 6.1 Constraint Index (CI)

A normalised indicator to rank candidate constraints:

$$\mathrm{CI}_s = \alpha\,\tilde{P}_s + \beta\,\tilde{Q}_s + \gamma\,\tilde{L}_s + \delta\,\tilde{D}_s,$$

Where for sector $s$:

- $P_s$: relative price/price change;
- $Q_s$: queue/lead time/backlog;
- $L_s$: labour tightness (vacancy/unemployment, wage acceleration);
- $D_s$: import-dependency & single-point-of-failure score;
- $\alpha, \beta, \gamma, \delta$ are policy weights (set by the National Constraint Board; see §8).

High CI $\rightarrow$ strong candidate for "current constraint."

In practice, each component of the CI is normalised to ensure comparability across sectors and over time. Where volatility is high, indicators such as $P_s$, $Q_s$ and $L_s$ are z-scored relative to their rolling baselines, and the dependency score $D_s$ is scaled to a common range. The weights $(\alpha, \beta, \gamma, \delta)$ are chosen such that $\alpha + \beta + \gamma + \delta = 1$ for interpretability, and are calibrated using historical shock episodes, input–output propagation studies, and the democratic weighting process described in Appendix A6. Sensitivity analysis on alternative weight vectors is reported in the Constraint Dashboard to demonstrate robustness.

Propagation of constraint pressure into headline inflation can be expressed in reduced form as:

$$\Delta\pi_t = \sum_s \omega_s\,\mathrm{IRI}_s(t) \;+\; \varepsilon_t,$$

where $\omega_s$ captures sectoral expenditure weights and elasticities, and $\varepsilon_t$ collects residual shocks. While not a structural model, this reduced form approximates how constraint relief in high-weight sectors yields disproportionate effects on $\pi_t$.

### 6.2 Inflation Decomposition

Inflation decomposition is essential in CDM because inflation is interpreted as a signal of real-resource stress rather than the result of monetary expansion alone. To use inflation operationally, the National Constraint Board (NCB) disaggregates headline CPI into analytically distinct components that correspond to identifiable real constraints. This allows the NCB to geo-locate and sector locate bottlenecks, distinguish domestic from imported pressures, and target constraint-relief interventions with precision.

Operationally, the decomposition combines data at different frequencies: monthly or higher-frequency sectoral price indices (ONS CPI and PPI breakdowns, energy price series), monthly labour-market indicators, quarterly or annual input–output tables, and, where available, administrative microdata on queues and backlogs. The National Constraint Board aggregates these series into a consistent, regularly updated decomposition that can be used for both near-term diagnosis and medium-term planning.

We decompose observed inflation into four drivers:

1. **Supply-Constraint Inflation (SCI):** Price pressures arising from binding real-resource limits in the domestic economy, including energy generation and grid capacity, transportation, logistics, agricultural yields, critical materials, and other throughput- limiting constraints.

2. **Demand-Pressure Inflation (DPI):** Price increases resulting from aggregate or sectoral demand exceeding available capacity. DPI is associated with tight labour markets ($L_s/\bar{L}_s$), long queues or backlogs ($Q_s/\bar{Q}_s$), and low short-run supply elasticity.

3. **External Price Transmission Inflation (EPTI):** Imported inflation transmitted through the exchange rate, international commodity prices, foreign supply-chain disruptions, and global transportation costs. This captures the extent to which global shocks (energy, food, freight, semiconductors, fertiliser) manifest domestically.

4. **Administered/Regulated Price Inflation (API):** Price changes resulting from policy or regulatory adjustments such as utility price caps, transport fares, excise duties, regulated rents, and administered charges. These effects are independent of supply or demand conditions.

For each sector $s$, observed price changes are decomposed as:

$$P_s = P_s^{SCI} + P_s^{DPI} + P_s^{EPTI} + P_s^{API},$$

where the superscripts indicate the contribution of each channel. The NCB estimates each component using sectoral price series, cost-share weights, high-frequency labour-market data, international price indices, energy-intensity metrics, and the UK Input–Output Tables.

### 6.2.1 Methodology

The decomposition proceeds in four stages:

1. **Sectoral Price Attribution.** Each sector's real price index is decomposed into inputs associated with energy, materials, labour, traded goods, logistics, and regulated components. Energy shares, import shares, and labour shares determine the exposure of each sector to SCI, EPTI, and DPI respectively.

2. **Pass-Through Modelling.** The NCB applies pass-through coefficients estimated from historical data and shock episodes to allocate observed price changes to their most likely drivers. For example, a sector with high import intensity and low wage pressure is more likely to exhibit EPTI rather than DPI.

3. **Supply-Chain Propagation.** Upstream bottlenecks propagate through the supply network. Using the Leontief inverse $M$ (Appendix A7), the NCB estimates propagation effects:

$$\Delta\pi = M \cdot \Delta P,$$

where $\Delta P$ is the vector of sectoral price changes. This allows the NCB to identify upstream constraints that contribute disproportionately to CPI.

**4. Geospatial Decomposition.** Inflation pressures are mapped to regions using local authority data on transport congestion, grid-connection times, labour-market tightness, and industrial structure. This geospatial mapping enables targeted, place-based constraint relief (e.g. energy nodes, NHS theatre clusters, port regions).

### 6.2.2 Operational Role in CDM

Inflation decomposition is not merely descriptive; it drives policy selection. The decomposition identifies:

- sectors with binding real constraints (high $P_s^{SCI}$ or $P_s^{DPI}$),
- sectors transmitting imported inflation (high $P_s^{EPTI}$),
- sectors affected primarily by regulatory changes ($P_s^{API}$),
- constraint propagation paths through the supply network,
- sectors where fiscal intervention yields the highest capacity gain.

These insights feed directly into the Constraint Index (CI), the Fiscal Targeting Rule, and the prioritisation decisions of the NCB. For example, if energy prices are elevated but the decomposition reveals the rise to be almost entirely external (high $P_s^{EPTI}$, low $P_s^{SCI}$), policy emphasis shifts from domestic demand-management to strategic reserves, import diversification, or accelerated renewable deployment. Conversely, if NHS inflation is driven by DPI or SCI (high queues, labour shortages), the correct response is targeted capacity expansion, not general interest-rate tightening.

In summary, inflation decomposition provides the diagnostic map that links observed price movements to underlying constraints, guiding the NCB's operational focus and ensuring that CDM responds to inflation at its source rather than through economy-wide suppression.

### 6.3 Dual Constraint Equations: Diagnostic and Macro-Inflation

CDM distinguishes carefully between diagnostics and macro-dynamics. Policymakers need to know both *where* constraints are binding (for prioritisation) and *how* those constraints translate into inflation risk (for macro stabilisation). To meet these distinct needs, we construct two related indices from a common indicator set: a diagnostic Constraint Identification Index ($\text{CI}_s$) and an Inflation Risk Index ($\text{IRI}_s$) that links constraint pressures to system-wide inflation risk.

In Constraint-Driven Macroeconomics we use two related but distinct equations built from the same underlying indicators $P_s, Q_s, L_s, D_s$:

(a) a **diagnostic** equation that identifies which sector $s$ is currently acting as a binding constraint; and

(b) a **macrodynamic** equation that estimates the inflationary impact of combined constraints, including external fragility.

These are:

- the *Constraint Identification Index* $\text{CI}_s$; and
- the *Inflation Risk Index* $\text{IRI}_s$.

For each sector $s$ we track:

- $P_s$: relative price level or price-change rate ($P_s$);
- $Q_s$: queue, lead-time, and backlog indicators ($Q_s$);

- $L_s$: labour tightness (vacancy-to-unemployment ratios, wage acceleration) ($L_s$);
- $D_s$: import-dependency and single-point-of-failure fragility ($D_s$).

Each of $P_s, Q_s, L_s$ can be normalised relative to a historical baseline for that sector, denoted with a bar (e.g. $\bar{P}_s$).

#### 6.3.1 Constraint Identification Index $\mathrm{CI}_s$ (Diagnostic)

The original Constraint Index is primarily a **diagnostic** tool: it identifies which sectors are running "hot" relative to their own history and are therefore strong candidates for being the current real constraint on national throughput.

We can write it compactly as:

$$\mathrm{CI}_s = \alpha \cdot \frac{P_s - \bar{P}_s}{\bar{P}_s} + \beta \cdot \frac{Q_s}{\bar{Q}_s} + \gamma \cdot \frac{L_s}{\bar{L}_s} + \delta \cdot D_s \tag{1}$$

where:

- $(P_s - \bar{P}_s)/\bar{P}_s$ captures the percentage deviation of sectoral prices from normal;
- $Q_s/\bar{Q}_s$ measures the ratio of current queues/lead times/backlogs to their baseline;
- $L_s/\bar{L}_s$ measures how tight the labour market is relative to normal conditions;
- $D_s$ is the sector's dependency and single-point-of-failure risk score;
- $\alpha, \beta, \gamma, \delta$ are policy weights chosen by the National Constraint Board (NCB).

A high $\mathrm{CI}_s$ indicates that sector $s$ is a strong candidate for being the *current constraint*. The index is primarily used to rank sectors and prioritise constraint-relief interventions, not to forecast aggregate inflation directly.

#### 6.3.2 Inflation Risk Index $\mathrm{IRI}_s$ (Macro-Inflation)

While $\mathrm{CI}_s$ answers *"where is the bottleneck?"*, it does not in itself show how constraints interact to produce inflation. For that task we define an **Inflation Risk Index**:

The $\mathrm{CI}_s$ provides a ranking of where constraints are currently binding. The $\mathrm{IRI}_s$ extends this by linking constraint intensity to expected inflationary spillovers, using a multiplicative structure to capture the compounding of pressures:

$$\mathrm{IRI}_s = (w_p P_s + w_q Q_s + w_l L_s) \cdot (1 + \kappa D_s) \tag{2}$$

Here:

- $w_p, w_q, w_l$ are weights reflecting the relative importance of price signals, operational congestion, and labour tightness in sector $s$;
- $D_s$ is the sector's external fragility score ($D_s$);
- $\kappa$ is a scaling parameter that governs how strongly external fragility amplifies domestic constraints.

We can interpret the two brackets as:

$$C_{\text{domestic},s} = w_p P_s + w_q Q_s + w_l L_s,$$

$$C_{\text{external},s} = 1 + \kappa D_s.$$

$C_{\text{domestic},s}$ is a measure of **domestic constraint pressure**; $C_{\text{external},s}$ is the **amplification factor** created by import dependency and single points of failure.

Formally, the dependency metric $D_s$ combines (i) import dependence or concentration, (ii) single-point-of-failure risk, and (iii) strategic criticality:

$$D_s = w_1 \,\mathrm{ID}_s + w_2 \,\mathrm{SPOF}_s + w_3 \,\mathrm{SC}_s,$$

with $w_1 + w_2 + w_3 = 1$. The weights are set through policy deliberation and empirical calibration as described in Appendix A6.

The multiplicative structure captures a core CDM insight: external shocks do not merely add to domestic constraints; they magnify them. A given level of domestic stress in $P_s, Q_s, L_s$ will produce much higher inflation risk when $D_s$ is large (fragile, import-dependent supply) than when $D_s$ is small (diversified, resilient supply).

### 6.4 Interpreting High CI and High IRI Values

The Constraint Index ($\mathrm{CI}_s$) and Inflation Risk Index ($\mathrm{IRI}_s$) capture two distinct but complementary dimensions of sectoral stress. $\mathrm{CI}_s$ measures the *current* degree of constraint pressure relative to the sector's historical norms. $\mathrm{IRI}_s$ measures the *future* inflationary leverage of a sector, based on its upstream position in the input–output network and its propagation multipliers. This subsection sets out how the National Constraint Board (NCB) should interpret high values for each index and their implications for policy prioritisation.

#### Statistical Thresholds

Because each component of $\mathrm{CI}_s$ is normalised using rolling multi-year baselines (ratio-normalised or z-scored), the resulting index is interpretable on a standard-deviation scale. Typical thresholds are:

- $\mathrm{CI}_s < 0.5$: low constraint pressure; sector close to normal conditions.
- $0.5 \leq CI_s < 1.0$: moderate strain; early-warning signal.
- $\mathrm{CI}_s \geq 1.0$: high constraint pressure; one standard deviation above historic norms.
- $\mathrm{CI}_s \geq 2.0$: critical constraint; statistically rare and consistent with severe backlogs, sharp relative-price acceleration, or acute labour scarcity.

The same logic applies to $\mathrm{IRI}_s$, where higher values indicate strong input–output centrality and high propagation multipliers.

#### Cross-Sector Prioritisation

Beyond absolute thresholds, the NCB must prioritise sectors by their *relative* levels of pressure. Each quarter, sectors are ranked by $\mathrm{CI}_s$, with priority tiers assigned as follows:

- **Tier 1**: Top three sectors by $\mathrm{CI}_s$ (binding national constraints).
- **Tier 2**: Next five sectors (developing constraints).
- **Tier 3**: Remaining sectors (monitoring only).

This ranking ensures that capacity-building programmes are targeted where they deliver the largest throughput gains per unit of sovereign spending.

#### Interpreting High IRI Values

$\mathrm{IRI}_s$ reflects a sector's upstream position in the supply network and its potential to generate system-wide inflation if it tightens further. Empirically and from the structure of the Leontief inverse:

- $\mathrm{IRI}_s > 1.0$: sector lies in the top quartile of propagation multipliers.

- $\text{IRI}_s > 1.5$: sector is an upstream hub; shocks spill over into a wide range of downstream industries.
- $\text{IRI}_s > 2.0$: macro-critical sector; small capacity constraints produce large, economy-wide inflation effects.

Examples include electricity generation, grid interconnection, transformer manufacturing, fuel logistics, key industrial chemicals, and port throughput.

**Policy Implications: CI–IRI Matrix**

The NCB should classify sectors using a two-dimensional rule:

| | Low $\text{IRI}_s$ | High $\text{IRI}_s$ |
|---|---|---|
| Low $\text{CI}_s$ | Routine monitoring | Prepare pre-emptive capacity plans |
| High $\text{CI}_s$ | Localised constraint relief | **Top national priority (CDM core)** |

The upper-right quadrant (high $\text{CI}_s$, high $\text{IRI}_s$) identifies the sectors whose relief produces the greatest reduction in inflation risk per pound of sovereign spending. These are the macro-level "taps" in the system: upstream bottlenecks whose dysfunction produces broad inflation downstream.

**Rationale for Thresholds**

The thresholds are grounded in (i) the statistical interpretation of normalisation, (ii) macro-prudential practice (risk-weighted indicators in banking and systemic importance scoring), and (iii) input–output propagation theory. High $\text{CI}_s$ signals that aggregate demand is pressing against real resource limits in that sector. High $\text{IRI}_s$ indicates that constraints in that sector will generate multi-sector inflation via the input–output network. Together, they provide a transparent and replicable basis for prioritising constraint-relief programmes and for linking inflation diagnostics to operational capacity planning.

### 6.5 Sectoral Case Studies: Applying $\text{CI}_s$ and $\text{IRI}_s$

To illustrate the use of the two equations in practice, we consider two stylised sectors:

(1) Energy (gas/electricity) under an external shock; and

(2) NHS elective care with severe domestic congestion but low external fragility.

#### 6.5.1 Example 1: Energy Sector Under External Shock

Consider the energy sector, $s =$ Energy, during a period of gas and electricity price turbulence.

Assume the following normalised indicator values relative to historical baselines:

$$\begin{aligned}
\frac{P_s - \bar{P}_s}{\bar{P}_s} &= 0.40 && \text{(energy prices 40\% above normal)} \\
\frac{Q_s}{\bar{Q}_s} &= 1.50 && \text{(50\% longer lead times / delivery lags)} \\
\frac{L_s}{\bar{L}_s} &= 1.20 && \text{(20\% tighter labour market than usual)} \\
D_s &= 5 && \text{(extremely fragile import-dependent supply).}
\end{aligned}$$

For the diagnostic equation (1), let the NCB choose:

$$\alpha = 0.4, \quad \beta = 0.3, \quad \gamma = 0.1, \quad \delta = 0.2.$$

Then:

$$\begin{aligned}
\mathrm{CI}_{\mathrm{Energy}} &= 0.4 \cdot 0.40 + 0.3 \cdot 1.50 + 0.1 \cdot 1.20 + 0.2 \cdot 5 \\
&= 0.16 + 0.45 + 0.12 + 1.00 \\
&= 1.73.
\end{aligned}$$

If, for example, $\mathrm{CI}_s > 1.0$ is taken as a threshold for "active constraint", this places the energy sector firmly in the binding-constraint category.

Now consider the Inflation Risk Index (4). Suppose for this sector we set:

$$w_p = 0.5, \quad w_q = 0.3, \quad w_l = 0.2, \quad \kappa = 0.1.$$

Domestic constraint pressure:

$$\begin{aligned}
C_{\mathrm{domestic,Energy}} &= 0.5 \cdot 0.40 + 0.3 \cdot 1.50 + 0.2 \cdot 1.20 \\
&= 0.20 + 0.45 + 0.24 \\
&= 0.89.
\end{aligned}$$

External amplification:

$$C_{\text{external,Energy}} = 1 + 0.1 \cdot 5 = 1.5.$$

Hence:

$$\text{IRI}_{\text{Energy}} = 0.89 \times 1.5 \approx 1.34.$$

Interpretation:

- $\text{CI}_{\text{Energy}} = 1.73$: energy is a clear operational bottleneck relative to its own baseline.
- $\text{IRI}_{\text{Energy}} \approx 1.34$: the same constraint is also a strong driver of inflation risk, because external fragility ($D_s = 5$) significantly amplifies domestic pressures.

This stylised example mirrors recent experience in which moderate domestic stresses in energy sectors were transformed into major inflation episodes by high and concentrated import dependency.

#### 6.5.2 Example 2: NHS Elective Care (High $Q_s$ and $L_s$, Low $D_s$)

Now consider NHS elective care: a sector that is heavily constrained domestically (queues and labour), but far less exposed to import fragility than, say, energy or critical medicines.

Assume:

$$\begin{aligned}
\frac{P_s - \bar{P}_s}{\bar{P}_s} &= 0.05 && \text{(costs 5\% above normal)} \\
\frac{Q_s}{\bar{Q}_s} &= 2.00 && \text{(queues and backlogs double the norm)} \\
\frac{L_s}{\bar{L}_s} &= 1.50 && \text{(significant labour tightness)} \\
D_s &= 1 && \text{(low–moderate external fragility).}
\end{aligned}$$

Using the same diagnostic weights:

$$\alpha = 0.4, \quad \beta = 0.3, \quad \gamma = 0.1, \quad \delta = 0.2,$$

we obtain:

$$\begin{aligned}
\text{CI}_{\text{NHS}} &= 0.4 \cdot 0.05 + 0.3 \cdot 2.00 + 0.1 \cdot 1.50 + 0.2 \cdot 1 \\
&= 0.02 + 0.60 + 0.15 + 0.20 \\
&= 0.97.
\end{aligned}$$

NHS elective care is therefore very close to being a binding constraint domestically, driven primarily by large queues and labour scarcity.

Now compute its Inflation Risk Index:

$$w_p = 0.5, \quad w_q = 0.3, \quad w_l = 0.2, \quad \kappa = 0.1.$$

Domestic pressure:

$$\begin{aligned} C_{\text{domestic,NHS}} &= 0.5 \cdot 0.05 + 0.3 \cdot 2.00 + 0.2 \cdot 1.50 \\ &= 0.025 + 0.60 + 0.30 \\ &= 0.925. \end{aligned}$$

External amplification:

$$C_{\text{external,NHS}} = 1 + 0.1 \cdot 1 = 1.1.$$

Hence:

$$\text{IRI}_{\text{NHS}} = 0.925 \times 1.1 \approx 1.02.$$

Interpretation:

- $\text{CI}_{\text{NHS}} = 0.97$: NHS elective care is close to being a binding constraint in terms of domestic throughput and service delivery.
- $\text{IRI}_{\text{NHS}} \approx 1.02$: its contribution to aggregate inflation risk is significant but smaller than that of the energy sector, largely because its external fragility term ($D_s$) is much lower.

This illustrates an important CDM distinction: a sector can be acutely constrained in real terms (high $Q_s$, high $L_s$) without necessarily being the dominant driver of inflation if external fragility is low. Conversely, even modest domestic pressures can become highly inflationary when combined with extreme external dependency.

In summary:

- $\text{CI}_s$ identifies *where* constraints bind and which sectors most urgently require capacity relief.
- $\text{IRI}_s$ estimates *how* those constraints, given external fragility, translate into system-wide inflation risk.

### 6.6 Weight Selection Methodology

The weighting parameters $(\alpha, \beta, \gamma, \delta)$ determine the relative importance of price instability, queue or backlog pressure, labour tightness, and structural dependency within the Constraint Index. They ensure that the CI reflects both empirical evidence and democratic priorities, rather than an implicit or opaque optimisation criterion.

The National Constraint Board (NCB) determines the weights through a three-stage calibration process. First, analysts produce a technical baseline using historical shock transmission, inflation decomposition, sectoral elasticity estimates, and input-output propagation studies. This identifies which forms of stress (prices, backlogs, labour scarcity, or structural fragility) have historically generated the strongest macroeconomic spillovers.

Second, the baseline is adjusted for systemic risk and resilience needs. Sectors exposed to high import concentration, single-point failures, or geopolitical vulnerabilities receive a higher weighting on the dependency term ($\delta$), reflecting the outsized macroeconomic cost of fragility even when current prices or queues appear normal.

Third, the NCB submits the proposed weights for parliamentary review. Because CDM makes the trade-offs explicit, elected representatives can adjust the weights to reflect social priorities, strategic objectives, or electoral mandates (for example, elevating $\beta$ and $\gamma$ during NHS backlog crises, or raising $\delta$ during periods of heightened geopolitical risk). This embeds democratic legitimacy without compromising methodological rigour.

The weights are reviewed annually, or more frequently during periods of unusual volatility or structural change. Sensitivity analysis—examining how alternative weights alter the ranking of constraints—is published as part of the quarterly Constraint Dashboard. This ensures that the prioritisation process remains transparent, interpretable, and reproducible.

### 6.7 Throughput & Slack Map

A national map of capacity utilisation (labour categories, energy nodes, critical materials, housing near jobs, transport corridors). Updated monthly; published quarterly.

### 6.8 Fiscal Targeting Rule (FTR)

Allocate incremental public spending first to sectors with **highest CI** *and* highest near-term elasticity of capacity expansion (fastest relief per pound and per month).

## 7 Policy Instruments (Aligned to the Constraint)

In CDM, policy instruments are grouped into three complementary families. First, *capacity-elevating tools* expand real throughput in the constrained sector (public investment, targeted procurement, skills and migration, public options). Second, *demand-shifting tools* temporarily reallocate demand away from overstressed resources (time-limited taxes, rebates, rationing, prioritisation regimes). Third, *regulatory and coordination tools* streamline processes and subordinate non-critical uses of scarce inputs. The bullet list below can be read through this lens: each instrument is selected and sequenced to either elevate capacity at the constraint, cool demand upon it, or align the rest of the system around it.

- **Targeted Sovereign Spending:** Direct procurement, grants, or public production.
- **Taxation as Resource Release:** Use time-limited surtaxes or targeted rebates to shift demand away from overstressed sectors and free real resources (not to "fund" spending).
- **Credit Guidance:** Preferential terms via state banks/infrastructure bank for constraint-relief investments; macro-prudential brakes where demand overheats constrained areas.
- **Migration & Skills:** Fast-track visas for critical occupations; paid training & apprenticeships with job guarantees.
- **Regulatory Streamlining:** One-stop permitting for constraint-relief projects; sunset emergency waivers.
- **Public Options:** Stand up temporary public production/coordination capacity (e.g., modular housing factories, grid-tie teams).

### Private Finance and Credit Alignment

CDM does not treat private finance as an external or neutral backdrop. Banks, institutional investors, and capital markets shape where real resources flow and how quickly constraint-relief projects can scale. The aim is not to supplant private finance but to align it with the constraint agenda and to discourage credit creation that worsens bottlenecks or fuels speculative pressure in already-constrained sectors.

In practical terms, the National Constraint Board and the macroprudential authorities would coordinate to:

- **Signal priority sectors and projects.** The Constraint Dashboard and annual Constraint Budget explicitly identify sectors and programmes that require elevation (e.g. grid nodes, NHS throughput, housing near jobs). These act as focal points for banks and investors, de-risked by sovereign backing or guarantees where appropriate.

- **Use credit guidance and prudential tools.** Regulators can lower risk weights, capital requirements, or liquidity coverage penalties for lending that genuinely contributes to constraint relief, and raise them for lending that amplifies fragility (for example highly leveraged real-estate speculation in supply-constrained areas, or exposure to high-$D_s$ imports when domestic substitution is a priority).

- **Crowd-in private capital via public anchors.** The National Infrastructure Bank (and analogous public entities) can provide first-loss capital, long-dated funding, or co-investment in constraint-elevating projects. This crowds in private lenders and investors while keeping project selection anchored to CI, IRI, and $D_s$ metrics.

- **Align disclosure and taxonomy with constraints.** Just as climate taxonomies steer finance toward low-carbon assets, a CDM-informed taxonomy would classify assets and loans according to their effect on constraints (easing, neutral, or aggravating). Banks and funds would disclose the share of their balance sheet devoted to constraint relief, creating reputational and market incentives to support the programme.

- **Protect balance-sheet stability.** Because CDM targets real bottlenecks, not arbitrary debt ratios, it can be combined with robust microprudential standards. Banks are not asked to "fund" government spending; instead, they are steered away from credit booms in constrained sectors and toward investments that raise throughput and resilience, reducing systemic risk over time.

Under CDM, therefore, private finance remains decentralised and profit-seeking, but operates within a macro framework where the sovereign government sets the real-resource agenda. Credit growth is not suppressed across the board; it is channelled toward elevating constraints and away from activities that intensify $P_s$, $Q_s$, $L_s$, or $D_s$ in already-stressed sectors.

# 8 Institutional Architecture (UK)

## 8.1 National Constraint Board (NCB)

Mandate: Identify, prioritise, coordinate, and publish the constraint agenda.

- **Members:** Treasury (chair), Bank of England (data hub), ONS, National Infrastructure Commission, Department for Energy/Net Zero, Education/Skills, Health, Transport, BEIS; devolved administrations represented. (It may be desirable to further devolve the identification of constraints to a local level, via councils and mayoral bodies. This may result in additional metrics being required for the care sector, special educational needs, road maintenance and other areas that fall to councils. Assessment of these at a local level may illuminate constraints that have an effect at national level.)

- **Advisory finance panel:** representatives from commercial banks, building societies, pension funds, and other institutional investors participate in an advisory capacity. They provide information on credit conditions, pipeline finance, and investor appetite for constraint-relief projects, and receive clear signals about priority sectors and programmes. Formal decisions remain with the public members of the NCB, but the advisory panel ensures that private finance is integrated into, rather than orthogonal to, the constraint agenda.

- **Products:**
  - Quarterly Constraint Dashboard (CI rankings, inflation decomposition, progress KPIs).
  - Annual Constraint Audit published alongside the Budget.
  - Constraint Budget: a ring-fenced programme portfolio aligned to the top constraints.

This allocation of roles reflects existing institutional strengths rather than creating an entirely new bureaucracy. The Treasury already has budgetary authority and must ultimately sign off spending decisions; positioning it as chair ensures that constraint relief is integrated into fiscal events. The Bank of England has the richest high-frequency data on prices, credit conditions, and expectations, and is therefore well-placed to act as a sensor and scenario lab rather than a lone policy lever. ONS and the National Infrastructure Bank possess, respectively, the statistical infrastructure and long-horizon financing capabilities required to maintain robust dashboards and to support elevation projects. CDM therefore repurposes and coordinates core institutions around real constraints, rather than replacing them.

### 8.2 Treasury

From "budget keeper" to Throughput Manager. Designs FTR allocations, executes spending, reports on capacity gains per pound.

### 8.3 Bank of England

From "rate setter as primary" to Sensor and Coordinator: inflows of high-frequency prices, credit conditions, sectoral wage growth; runs scenario labs with Treasury.

### 8.4 ONS & National Infrastructure Bank

Data engineering, dashboarding, evaluation; provides long-horizon capital to elevate constraints.

## 9 Governance, Accountability, and Transparency

- **KPIs:** lead-time reductions, cost-per-unit of capacity added, sectoral inflation cooling, throughput growth, and distributional fairness.
- **Sunset & Review:** each constraint programme has explicit 6-, 12-, and 24-month milestones with go/stop/scale decisions.
- **Public Reporting:** dashboards and readable narratives; independent academic advisory panel.
- **Ethics & Equity:** ensure that constraint relief benefits households and SMEs, not only large incumbents; include fair work standards.

## 10 Case Studies (UK)

### 10.1 Energy & Grid (2026–2030)

- **Identify:** High CI from volatile energy prices, weak grid interconnections, installer shortages.
- **Exploit:** Dynamic demand management, maintenance backlogs cleared, inventory of "shovel-ready" grid nodes.
- **Subordinate:** Prioritise copper, transformers, power-electronics labour; defer non-critical projects that compete for the same crews.
- **Elevate:**
  - Train 30k electricians/lineworkers with paid apprenticeships.
  - Fast-track substation builds and on-shore manufacturing of transformers.
  - Temporary migration corridors for high-skill teams.

**KPIs:** grid connection lead times ↓ 50%; wholesale price volatility ↓ 30%; ... renewable curtailment ↓.

Illustratively, suppose the baseline grid-connection backlog for renewable projects is 80 GW of capacity with a median connection time of 8–10 years. A targeted CDM programme might authorise and fund 30,000 additional electricians and lineworkers, bring forward 200 priority substations, and on-shore part of transformer production. If these measures collectively halve connection times and cut the backlog growth rate to near zero, the resulting increase in renewable throughput would both reduce the energy component of CPI and lower exposure to high $D_s$ scores in imported gas, simultaneously improving the CI and IRI profiles for the energy sector.

### 10.2 NHS Throughput (Elective Care)

- **Identify:** Theatre time and specialist nursing are constraints; long queues (Q) and wage pressure (L) confirm.
- **Exploit:** Theatre scheduling optimisation; overtime teams; weekend "max-list" clinics.
- **Subordinate:** Redirect capital and staff from lower-impact areas temporarily.
- **Elevate:** Train/retain surgical nurses and anaesthetists; modular theatres; AI triage pilots.
- **KPIs:** RTT (Referral-to-Treatment) days ↓; cancellations ↓; unit cost per completed pathway ↓.

For example, if baseline elective-care backlogs stand at 7.8 million cases with average Referral-to-Treatment (RTT) times of 40 weeks, a CDM-aligned programme might target a reduction to 20–24 weeks over a 3–5 year horizon. On the capacity side, this could involve funding an additional 3,000 surgical nurses and anaesthetists, commissioning 50 modular theatres in high-pressure regions, and expanding weekend and evening operating lists. On the demand side, targeted triage and prevention programmes reduce inflow. The combined effect is a sustained decline in the $Q_s$ and $L_s$ components for NHS elective care, improving both its CI ranking and its contribution to aggregate inflation risk.

### 10.3 Housing Near Jobs

- **Identify:** Build-out blocked by planning throughput and skilled trades.
- **Exploit:** Standardised designs; batch approvals; public land release.

- **Subordinate:** Timber and MMC capacity prioritised; align transport funds to sites.
- **Elevate:** Public MMC plants; accelerated training; targeted migration.
- **KPIs:** median approval time ↓; completions near employment hubs ↑; rent inflation contribution ↓.

A stylised CDM housing programme might aim to increase completions near major employment hubs by, say, 50,000 units per year over a five-year period, focused on regions with the highest rent and commute-time pressures. Planning throughput reforms (standardised designs, batch approvals, dedicated planning teams for priority zones) could cut median approval times from 24 months to 9–12 months. Parallel investments in timber and MMC capacity, supported by the FTR, would ensure that material and labour constraints are elevated rather than merely shifted. As these changes feed through, rent inflation contributions in affected areas would fall, and the housing-related elements of $Q_s$, $L_s$ and $D_s$ would improve.

# 11 Quantitative Framework

## 11.1 Allocation Algorithm (Sketch)

Let $s \in \{1, \ldots, S\}$ index candidate sectors and let $t$ index time. Each sector receives an allocation $\Delta S_{s,t}$ from the constraint budget. Capacity relief feeds back into CI and IRI as:

$$\mathrm{CI}_{s,t+1} = \mathrm{CI}_{s,t} \; - \; \lambda_s \, G_s(\Delta S_{s,t}),$$

where $\lambda_s$ is a conversion parameter and $G_s(\cdot)$ is the sectoral capacity-gain function.

The allocation problem can be expressed generically as:

$$\max_{\{\Delta S_s\}} \quad \sum_s w_s \, G_s(\Delta S_s) \quad \text{s.t.} \quad \sum_s \Delta S_s = \Delta S_{\text{budget}}, \qquad \Delta S_s \geq 0.$$

1. Rank sectors by $\mathrm{CI}_s$.
2. For top $k$ sectors, estimate Capacity Gain Function:

$$G_s(\Delta S_s) = \text{capacity added per pound spent within horizon } H.$$

3. Solve constrained optimisation:

$$\max_{\{\Delta S_s\}} \sum_s w_s \cdot G_s(\Delta S_s)$$

subject to:

$$\sum_s \Delta S_s = \Delta S_{\text{budget}}, \quad \Delta S_s \geq 0.$$

4. Iterate quarterly with KPI feedback; update $G_s$, $w_s$, and $\text{CI}_s$.

For illustration, suppose the NCB applies a minimum return threshold $R_{\min}$ and, by selecting all qualifying constraint-relief interventions, arrives at a Constraint Budget totalling £10 billion. This figure is thus an outcome of the real-resource and return analysis, not a predetermined financial limit.

$$G_E(\Delta S_E) = 0.8\Delta S_E, \quad G_N(\Delta S_N) = 1.0\Delta S_N, \quad G_H(\Delta S_H) = 0.6\Delta S_H,$$

where $G_s$ is measured in percentage reductions of the relevant backlog or lead-time metric per billion pounds invested. Let policy weights reflect social priorities and macro impact as $(w_E, w_N, w_H) = (0.35, 0.45, 0.20)$. The NCB then solves:

$$\max_{\Delta S_E, \Delta S_N, \Delta S_H} 0.35\, G_E(\Delta S_E) + 0.45\, G_N(\Delta S_N) + 0.20\, G_H(\Delta S_H)$$

subject to

$$\Delta S_E + \Delta S_N + \Delta S_H = 10, \quad \Delta S_s \geq 0.$$

Given the linear form of $G_s$, the solution allocates the bulk of the budget to the sector with the highest product $w_s \cdot G_s$ (here NHS elective care), while maintaining a minimum strategic allocation to Energy and Housing to respect resilience and distributional objectives. In practice, the optimisation would incorporate diminishing returns, sectoral sub-budgets, and political constraints, but the logic is the same: allocate additional spending where it buys the most constraint relief per pound, given agreed priorities.

### 11.2 Inflation Feedback Rule

If sectoral inflation $\pi_s$ remains elevated despite $G_s$ progress, escalate to demand-shifting instruments (targeted taxes/rebates, rationing, public options) until $\pi_s$ normalises.

### 11.3 Leontief Propagation and Constraint Mapping

The input–output structure of the economy determines how a local constraint propagates into system-wide inflation. Constraint-Driven Macroeconomics uses the Leontief inverse to formalise these propagation effects and to identify which sectors generate the largest macroeconomic consequences when they become bottlenecked.

Let $A$ denote the input–output coefficient matrix, where $a_{ij}$ represents the value of inputs from sector $i$ required to produce one unit of output in sector $j$. Let $I$ denote the identity matrix. The Leontief inverse is defined as:

$$L = (I - A)^{-1}.$$

The element $L_{ij}$ measures the total (direct and indirect) effect on sector $i$ of a one-unit change in final demand in sector $j$. In the CDM setting, we apply the same logic to price or cost shocks: a constraint in sector $j$ (e.g. an energy or transformer bottleneck) generates price pressure in its immediate customers and, via them, throughout the network. Formally, if $\Delta P$ is the vector of sectoral price or unit-cost shocks, the propagated price impact is approximated by:

$$\Delta\pi \approx L \cdot \Delta P,$$

where $\Delta\pi$ is the vector of propagated inflation contributions.

Columns of $L$ therefore identify *constraint multipliers*: a large value for $L_{ij}$ indicates that sector $j$ is systemically important for sector $i$. Sectors whose shocks generate large values across many $i$ are macro-critical bottlenecks even if they are small in GDP terms (for example, transformer manufacturing or specialised components). This network perspective explains why upstream constraints in energy, logistics, or key materials can produce broad inflation while downstream sectors with high demand but weak network centrality have more localised effects.

In CDM, the Leontief inverse is not used as a forecasting device in isolation, but as an input to constraint governance:

- It helps identify *upstream* sectors whose constraints have disproportionate inflationary impact, informing the ranking of sectors by $\text{CI}_s$.
- It guides the Fiscal Targeting Rule by highlighting where an additional unit of capacity investment will yield the largest system-wide reduction in price pressure.
- It distinguishes between sectors that are primarily *sources* of constraint-induced inflation and those that are mainly *transmitters* or *victims* of upstream bottlenecks.

By combining inflation decomposition (which identifies where observed price changes originate) with Leontief-based propagation analysis (which shows how they spread), CDM turns headline inflation into a map of specific constraints and their macroeconomic leverage points.

## 12 Baseline Social Provision and Non-Constraint Budgets

Constraint-Driven Macroeconomics is not a proposal to subject all public spending to a throughput test. Societies choose, through democratic processes, to provide pensions, income support, disability benefits, social care, and other forms of non-market provision that may not raise measured throughput directly but are central to wellbeing, stability, and legitimacy. CDM therefore distinguishes between:

1. a **Baseline Social Provision Envelope**, covering core entitlements such as pensions, social security, basic income support, and essential care; and
2. a **Constraint Budget**, which allocates additional spending to the elevation of identified bottlenecks using the CI, IRI, and $D_s$ metrics.

The Baseline Social Provision Envelope is set primarily by political and ethical judgement, not by the constraint algorithm. It reflects choices about intergenerational equity, social insurance, and the desired distribution of income and security. From an MMT perspective, such spending is financed in exactly the same way as any other sovereign outlay: the state creates the currency when it pays pensions or benefits, and deletes it when taxes are paid. The operational question is not "can we afford pensions?" but "does the combined level of spending, including pensions, push demand beyond real capacity in particular sectors?"

CDM interacts with this envelope in two ways. First, it treats the baseline as a given when constructing the Constraint Budget: the optimisation in Section 11 sec:quantitative-framework applies to the incremental fiscal space allocated to constraint relief, not to the entirety of public spending. Second, the framework monitors the sectoral effects of baseline social spending. If increases in pensions or care benefits are found to raise demand disproportionately in a sector that is already a binding constraint (e.g. housing in specific regions, or particular medical services), the NCB can recommend targeted demand-shifting or capacity-elevating measures in those sectors. The objective is not to cut pensions or benefits, but to ensure that their distribution and indexation are compatible with maintaining price stability.

In summary, CDM adds a layer of real-resource governance on top of, and alongside, a politically determined social floor. It preserves the automatic stabiliser role of benefits and pensions, while providing a disciplined method for managing the inflation and capacity consequences of those programmes at the margin.

# 13 Implementation Roadmap

## 13.1 Phase 0 (0–3 months)

Establish NCB secretariat; publish first Constraint Baseline. Stand up data pipelines; define CI weights; choose three pilot constraints.

## 13.2 Phase 1 (3–12 months)

Launch pilot programmes; publish monthly dashboards; begin skills & migration fast tracks. Codify "Constraint Budget" section in the Budget Statement.

## 13.3 Phase 2 (12–24 months)

Scale effective pilots nationally; embed Constraint Audit into fiscal events. Introduce performance-linked procurement and outcome-based grants.

## 13.4 Phase 3 (24–48 months)

Institutionalise CDM; expand to regional Constraint Labs. Publish international template for sovereign issuers.

# 14 Risks and Mitigations

- **Measurement Error / False Constraint:** Use triangulation (prices, queues, wages, dependencies); pivot fast.
- **Political Capture:** Transparent dashboards, independent advisory board, competitive procurement.
- **Inflation Overshoot:** Pair capacity builds with targeted demand shifting; maintain contingency import channels.
- **Supply Chain Shocks:** Develop diversified supplier pools; maintain strategic reserves; surge contracts.
- **Skills Pipeline Lag:** Combine training stipends, retention bonuses, migration bridges, automation.

### Methodological Limitations

The CDM framework relies on several data and modelling assumptions that introduce limitations. First, many of the key indicators ($P_s$, $Q_s$, $L_s$, $D_s$) are drawn from data with different reporting frequencies: input–output tables are annual, labour and price series are monthly, and backlogs or lead-times vary by sector. This mismatch means real-time dashboards rely on partial nowcasting and interpolation. Second, the Capacity-Gain functions $G_s(\cdot)$ and conversion parameters $\lambda_s$ require empirical estimation, which will vary across time, sectors, and political choices. Third, the normalisation choices for CI and IRI (z-scores, min–max, or rolling averages) influence rankings, although sensitivity analysis mitigates this.

In addition, CDM is not a structural model of the entire economy. It provides a decision-support framework for identifying and relieving binding constraints, but it abstracts from distributional effects, behavioural feedbacks, and micro-level frictions except where they feed directly into indicators. Inflation propagation via the Leontief inverse captures medium-run spillovers, but does not model expectations, capital accumulation, or long-run innovation dynamics in detail. These limitations do not invalidate the framework, but define its proper scope: CDM complements, rather than replaces, broader macroeconomic analysis.

CDM does not eliminate uncertainty or the need for judgement. Its indicators are only as good as the underlying data, and many key series (such as input–output matrices or detailed supply-chain maps) are updated infrequently. Political feasibility may constrain the speed at which constraint-relief programmes can be implemented, and weight choices will always reflect value judgements as well as empirical evidence. The framework should therefore be understood as a disciplined decision-support system rather than a mechanical optimisation device: it structures trade-offs, makes assumptions transparent, and shortens feedback loops, but cannot substitute for democratic deliberation.

## 15 Comparison with Status Quo

| Dimension | Status Quo | CDM |
|---|---|---|
| Primary target | CPI via interest rate | Throughput & constraint relief |
| Fiscal stance | Ratio-driven (deficit/debt) | Resource-driven (CI & KPIs) |
| Inflation control | Blunt, economy-wide | Targeted, sector-specific |
| Accountability | Opaque | Dashboards & audits |
| Speed of response | Slow, pro-cyclical | Agile, iterative |

## 16 Addressing Common Critiques

- **"This is inflationary."** Spending is directed at capacity expansion; demand-shifting tools cool overheated sectors. Inflation falls as bottlenecks ease.
- **"Debt/GDP will rise."** Ratios are not operational constraints for sovereign issuers. Focus is on real capacity, not nominal stocks.
- **"Picking winners."** CDM picks constraints, not firms. The selection process is metric-driven and transparent.
- **"Complexity."** ToC reduces complexity by focusing only on the bottleneck; dashboards communicate progress clearly.
- **"This is central planning by another name."** CDM does not attempt to micromanage the entire economy or pick corporate winners. It identifies a small number of binding constraints using transparent indicators, then focuses public tools on relieving those constraints while leaving most allocation to markets. The aim is to remove bottlenecks that markets alone cannot address in time, not to replace decentralised decision-making.

## 17 Inflation Expectations under CDM

Traditional macroeconomic frameworks place inflation expectations at the centre of the inflation process, treating expected inflation as a principal driver of actual inflation. In New Keynesian and DSGE models, firms raise prices partly because they *anticipate* future inflation, workers negotiate wages based on *expected* cost-of-living increases, and central banks tighten policy to reshape those expectations. In these models, beliefs and expectations can generate inflation dynamics even in the absence of material constraints.

Constraint-Driven Macroeconomics takes a different view. In CDM, inflation expectations matter for the *speed* and *timing* of price adjustments, but they are not the fundamental cause of inflation. Instead, expectations are *endogenous* to real-resource conditions. When firms observe rising lead times, material shortages, or labour scarcity, they rationally anticipate higher future input costs and adjust prices accordingly. Likewise, workers increase wage demands when they experience rising housing, energy, or transport costs—all of which reflect underlying bottlenecks. Expectations amplify the effects of constraints; they do not generate sustained inflation in their absence.

This places constraints, rather than beliefs, at the root of inflation dynamics. The observed "wage–price spiral" is therefore better understood as a *constraint–price spiral* in which wage bargaining and price-setting adapt to underlying shortages. When constraints are relieved—for example by reducing backlogs, expanding sectoral capacity, or lowering import fragility—the informational basis for high inflation expectations collapses. Firms and workers then moderate price and wage adjustments, and rapid disinflation can occur even without suppressing aggregate demand.

Expectations remain operationally useful within CDM. High-frequency data on survey expectations, mark-up behaviour, forward-order prices, and negotiated wage settlements act as *sensors* of emerging constraints. They provide early-warning signals that a sector's $P_s$, $Q_s$ or $L_s$ indicators may be deteriorating. But in the CDM framework, the corrective action is directed at the underlying constraint—not at aggregate demand and not at the expectations themselves. By elevating the constraint, the system "anchors" expectations through improved supply responsiveness rather than through demand suppression.

In summary, CDM reframes inflation expectations as an amplification mechanism rather than a structural driver. Expectations respond to constraints, not vice versa. As constraints ease, expectations realign automatically. This approach offers a materially grounded and empirically consistent alternative to expectations-centric inflation control, and avoids the need for broad-based demand contraction when inflation is driven by real bottlenecks rather than by overheating.

**Relation to Empirical Work.** The expectations mechanism described in Section 17 creates measurable adjustments in prices and wages that can be used to validate constraint-relief interventions. High-frequency data on expectations act as leading indicators for underlying constraint dynamics, providing a further empirical check on the CDM approach.

## 18 Legal and Administrative Enablers (UK)

- Amend fiscal framework to introduce a **Constraint Budget** annex.
- Clarify the Bank of England's **data and coordination role** in statute or remit letter.
- Empower the National Infrastructure Bank for rapid, conditional financing of elevation projects.
- Create statutory authority for **temporary expedited permitting** on named constraint programmes with sunset clauses.

## 19 International Applicability

### Countries Eligible for Full CDM

Full implementation of CDM requires a state to issue its own non-convertible, floating currency, to borrow primarily in that currency, and to operate without a binding external or convertibility constraint. Countries meeting these conditions can treat sovereign spending as the primary instrument for relieving real constraints. Examples include:

- **United States, United Kingdom, Canada, Japan, Australia, New Zealand.** These states issue free-floating fiat currencies, hold negligible foreign-currency debt, and possess deep domestic financial systems. Their fiscal operations are not limited by external financing conditions, allowing the full CDM cycle—diagnosis, allocation, and constraint elevation—to operate as intended.
- **Norway, Sweden, Switzerland.** These countries maintain independent floating currencies, extremely low external liabilities, and robust institutional capacity. Their monetary regimes impose no convertibility or reserve requirements, enabling sovereign spending to be directed toward throughput expansion without exchange-rate fragility.
- **South Korea (qualified), Mexico (qualified), Brazil (qualified).** These states issue their own currencies and largely borrow domestically. While they face greater exposure to global capital flows, their exchange rates are formally floating, and their governments retain the capacity to conduct large-scale domestic-currency spending. CDM is fully implementable in principle, though the external constraint is more salient in practice.

In these countries, inflation risk is driven primarily by domestic capacity bottlenecks and import-fragility structures rather than by external financing constraints. CDM's combination of real-resource diagnostics, sovereign spending, and constraint-targeted investment can therefore be applied in its complete macroeconomic form.

### Countries Unable to Implement Full CDM: Reasons for Exclusion

The full CDM framework requires a state to issue its own non-convertible, floating currency, to have low exposure to foreign-currency debt, and to operate without a binding external or convertibility constraint. Several categories of countries therefore cannot implement CDM in its complete form. Their exclusion arises not from institutional weakness but from structural features of their monetary systems.

**1. Members of Currency Unions (Eurozone).** Eurozone states do not issue the currency in which their obligations are denominated. They face a binding external constraint via the ECB and Stability and Growth Pact rules. As currency *users*, they cannot employ sovereign spending as the primary constraint-elevation tool. CDM applies only in its operational ToC components.

**2. Countries Operating Fixed or Pegged Exchange Rates.** States that peg their currency—including Denmark (ERM II), Hong Kong (currency board), and Gulf states with USD pegs—must defend the parity through interest-rate or reserve adjustments. Their fiscal space is restricted by the peg itself. The external constraint dominates macro policy, preventing the use of unconstrained sovereign spending for constraint relief.

**3. Economies with High Foreign-Currency Debt or FX Exposure.** Countries with significant USD- or EUR-denominated liabilities face a hard external financing limit: sovereign spending in domestic currency can trigger balance-of-payments stress, depreciation, or capital flight. Many emerging and developing economies fall into this group (e.g. Thailand, Vietnam, South Africa, Malaysia, and parts of Latin America). They can use CI, IRI and $D_s$ diagnostics internally, but cannot treat fiscal space as fully sovereign.

**4. Countries with Currency Non-Convertibility or Heavy Capital Controls.** Some sovereign issuers operate managed exchange rates with limited convertibility (e.g. China). While these states can implement most of CDM, the presence of hard capital controls and a non-floating currency introduces a binding external constraint on the scale and timing of sovereign spending. They therefore adopt CDM with structural caveats.

**5. Sub-Sovereign Governments.** US states, Canadian provinces, UK local authorities and similar entities use a currency they do not issue. They face balanced-budget rules, borrowing limits, and insolvency risk. CDM applies only as an operational tool within a fixed budget envelope, not as a macro- fiscal framework.

In all excluded cases, the reason is the presence of a binding *external* or *convertibility* constraint: a requirement to defend an exchange rate, maintain foreign reserves, or service debt in another currency. These constraints prevent the use of sovereign spending as the primary lever for constraint elevation, limiting CDM to its diagnostic and operational components rather than its full macroeconomic form.

## 20 Empirical Agenda and Future Work

The empirical programme required to validate CDM consists of three stages. First, historical backtesting: the CI, IRI and $D_s$ indices should be constructed for recent shock episodes—pandemic supply-chain disruptions, energy crisis volatility, food and fertiliser shocks—and compared with realised inflation, lead-times, and throughput losses. This establishes whether CDM would have identified the correct constraints ex ante and whether the prioritisation implied by the Constraint Budget would have delivered more effective stabilisation than interest-rate adjustments alone.

Second, prospective monitoring: institutions such as the ONS, BoE, Ofgem, and sectoral regulators can supply high-frequency data to maintain a live Constraint Dashboard. Comparing its signals with subsequent inflation prints, PMI backlogs, and sector-specific bottleneck indicators provides an ongoing test of predictive accuracy. Third, pilot implementations: targeted CDM programmes in two or three key sectors—such as energy grid reinforcement, elective care throughput, or housing near jobs—would allow direct measurement of how capacity elevation translates into reductions in CI, IRI and realised inflation pressure.

Future research should extend the modelling foundations of CDM: improved estimation of $G_s(\cdot)$ functions; richer IO-based propagation models; integration with labour-market matching frictions; and formalisation of the interaction between constraint relief and inflation expectations. Much of this work can be undertaken with existing administrative and national-accounts datasets, providing a strong basis for iterative refinement of the framework.

Taken together, these extensions clarify the novelty, limitations, and empirical testability of CDM. They position the framework not merely as a conceptual synthesis but as a practical, data-driven system for fiscal strategy, inflation management, and long-term resilience building.

## 21 Conclusion

**Constraint-Driven Macroeconomics** turns macro policy into rigorous *systems management*. MMT lifts artificial financial limits; ToC focuses attention on what truly binds the system. Together they deliver a governance method that expands real output, cools inflation at the source, and makes government performance visible and accountable.

For policymakers, the implication is clear: inflation control is most effectively achieved by relieving binding constraints rather than suppressing aggregate demand. CDM provides the operational toolkit to achieve this.

## 22 Next Steps (Actionable)

1. Approve creation of the **National Constraint Board** and initial **Constraint Baseline**.
2. Select three pilot constraints (Energy/Grid, NHS Throughput, Housing Near Jobs).
3. Publish the first **Constraint Dashboard** and begin monthly reporting.
4. Commission a technical annex specifying CI weights, data sources, and the allocation algorithm.

## 23 Acknowledgements

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# Appendix A1 Technical Notes

This appendix provides the technical foundations for the construction, normalisation, and interpretation of the dual indices used in the CDM framework: the Constraint Index ($\mathrm{CI}_s$) and the Inflation Risk Index ($\mathrm{IRI}_s$). It also documents the baseline parameters, update cycle, and the underlying data sources that support their calculation.

## A1.1 Overview of the Dual Indices

CDM uses two complementary indicators for each sector $s$:

- **Constraint Index** ($\mathrm{CI}_s$) — measures current real-resource stress relative to the sector's historical norm. It reflects the degree to which a sector is functioning as a *binding constraint* in the present.
- **Inflation Risk Index** ($\mathrm{IRI}_s$) — measures the future inflationary leverage of a sector based on its upstream position in the input–output network and supply-chain propagation characteristics. It reflects the degree to which a sector is likely to *amplify and transmit* inflation if constraints worsen.

Taken together, the indices distinguish between:

- sectors that are tight now (high $\mathrm{CI}_s$),
- sectors that will cause inflation later (high $\mathrm{IRI}_s$),
- sectors that lie in both categories and form the core of CDM's prioritisation matrix.

## A1.2 Baseline Construction

Both $\mathrm{CI}_s$ and $\mathrm{IRI}_s$ use rolling multi-year baselines to define each sector's historical norm. These baselines ensure that the indices measure *structural deviation*, not short-run volatility or noise.

For each sector $s$ and variable $X_s$ (price, queue length, labour tightness, dependency score, propagation score), define:

$$\bar{X}_s = \text{mean over baseline window}, \qquad \sigma_{X_s} = \text{standard deviation over baseline window.}$$

The typical baseline window is **36–60 months** depending on the data series. Updates occur annually on a rolling basis. This approach:

- smooths seasonal patterns,

- ensures comparability across sectors,
- prevents one-off shocks from dominating the indices,
- reflects structural, not cyclical, stress.

### A1.3 Normalisation and Standardisation

Variables used in the indices differ in scale, distribution, and variance. CDM allows both:

- **ratio-normalisation** for variables with stable means:

$$\frac{X_s - \bar{X}_s}{\bar{X}_s},$$

- **z-scoring** for variables with higher variance or where the mean is not an appropriate scaling factor:

$$z(X_s) = \frac{X_s - \bar{X}_s}{\sigma_{X_s}}.$$

The National Constraint Board (NCB) determines the normalisation method for each variable based on data properties and sectoral characteristics.

### A1.4 Dependency Score ($D_s$)

The external fragility term $D_s$ captures the extent to which sector $s$ is exposed to supply-chain structures that magnify domestic constraint pressure. It is the sole external component in the Inflation–Risk Index (IRI) defined in Section 6.3.2, where

$$\text{IRI}_s = (w_p P_s + w_q Q_s + w_l L_s)\,(1 + \kappa D_s).$$

The dependency score is constructed as a weighted composite of three normalised sub-indicators:

$$D_s = w_1\, I_s^D \;+\; w_2\, \text{SPOF}_s \;+\; w_3\, SC_s, \qquad w_1 + w_2 + w_3 = 1, \tag{3}$$

where:

- $I_s^D$ measures **import dependence and geographic concentration** of key inputs to sector $s$, based on ONS Input–Output Tables, trade statistics, and supplier-location data;
- $\text{SPOF}_s$ measures **single-point-of-failure** exposure, capturing whether a sector relies on a small number of critical upstream suppliers or infrastructure nodes;

- $SC_s$ is a **strategic criticality** index, reflecting the degree to which disruption in sector $s$ poses systemic risks (e.g., energy, food, pharmaceuticals, grid infrastructure, defence-support industries).

Each component is normalised (z-score or 0–1 percentile scaling) to ensure cross-sector comparability. The policy weights $(w_1, w_2, w_3)$ are chosen by the National Constraint Board to reflect national priorities, such as reducing import exposure, improving resilience to concentrated supply structures, or strengthening strategic autonomy.

**Weighting Scheme for $w_1, w_2, w_3$.** The weights $(w_1, w_2, w_3)$ determine the relative importance of import dependency, single-point-of-failure exposure, and strategic criticality in the overall dependency score $D_s$. Their selection combines empirical analysis, expert judgement, and explicit democratic prioritisation.

- **Empirical evidence.** Historical contributions of each factor to inflation transmission, supply disruptions, and systemic shocks (using ONS Input–Output tables, BEIS security reviews, National Risk Register analyses, and NIC assessments).
- **Expert assessment.** Technical evaluations of sectors with specialised fragility (e.g. grid components, pharmaceuticals, semiconductors, defence supply chains), where SPOF risk or strategic dependence may dominate import levels.
- **Democratic priority-setting.** The NCB sets $(w_1, w_2, w_3)$ transparently, reflecting national risk appetite. For example, geopolitical tension may justify temporarily increasing the SPOF weight $w_2$, while long-term energy-transition strategy may increase $w_3$ for critical sectors such as transformers or gas infrastructure.

All weights are normalised such that $w_1 + w_2 + w_3 = 1$. They are reviewed annually, or sooner when material shifts in supply-chain conditions occur.

The amplification parameter $\kappa$ determines how strongly external fragility magnifies domestic constraint pressure. Combined with $D_s$, it forms the multiplicative factor $(1 + \kappa D_s)$ in the IRI, ensuring that external risk enters the inflation-risk calculation as a clear and transparent scaling of domestic stress rather than a separate functional form.

### A1.5 Construction of the Inflation–Risk Index (IRI)

The Inflation–Risk Index ($\text{IRI}_s$) is designed to quantify how strongly constraints in sector $s$ are likely to translate into inflationary pressure. In the main text (Section 6.3.2) we define:

$$\text{IRI}_s = \Big(w_p P_s + w_q Q_s + w_l L_s\Big)\Big(1 + \kappa D_s\Big), \tag{4}$$

where:

- $P_s$ is the sectoral price signal (level or change),
- $Q_s$ is a normalised index of queues, lead times, and backlogs,
- $L_s$ is a normalised indicator of labour tightness (vacancies, wage acceleration),
- $D_s$ is the sector's external fragility and dependency score,
- $w_p, w_q, w_l$ are policy weights on the domestic stress indicators,
- $\kappa$ is an amplification parameter that governs how strongly external fragility magnifies domestic constraint pressure.

It is useful to interpret the two brackets in (4) as:

$$C_{\text{domestic},s} = w_p P_s + w_q Q_s + w_l L_s, \qquad C_{\text{external},s} = 1 + \kappa D_s.$$

$C_{\text{domestic},s}$ measures the intensity of *domestic* constraint pressure in sector $s$, combining price signals, operational congestion, and labour tightness. $C_{\text{external},s}$ is an *amplification factor* that scales this domestic pressure up or down depending on the sector's exposure to external shocks and fragile supply structures.

The dependency metric $D_s$ is itself constructed from three components:

$$D_s = w_1 I_s^D + w_2 \text{SPOF}_s + w_3 SC_s,$$

with $w_1 + w_2 + w_3 = 1$, where:

- $I_s^D$ measures import dependence or geographic concentration of key inputs,
- $\text{SPOF}_s$ captures single–point–of–failure risks in critical supply chains,
- $SC_s$ reflects strategic criticality (for example, energy, food, defence–related inputs).

The weights $w_p, w_q, w_l, \kappa$ and $w_1, w_2, w_3$ are chosen by the National Constraint Board through a combination of empirical calibration and policy judgement (see Appendix A6). In this way, what we describe informally as *vulnerability* is not a separate variable; it is embedded in the construction of $D_s$ and in the choice of the amplification parameter $\kappa$ and the associated weights.

### A1.6 Fiscal Envelope and Real-Resource Budgeting

The fiscal-targeting mechanism assumes an overall sovereign spending envelope that is constrained not by finance but by real-resource availability and inflation control. Let $\Delta S_{budget}$ denote the additional sovereign spending consistent with:

$$\pi_{expected} \leq \pi^*, \qquad \text{and} \qquad \text{real-resource slack } R \geq 0.$$

The NCB allocates spending across sectors $\Delta S_s$ by solving the constraint-relief optimisation problem (see §10):

$$\max_{\Delta S_s \geq 0} \sum_s w_s G_s(\Delta S_s) \quad \text{s.t.} \quad \sum_s \Delta S_s = \Delta S_{budget},$$

where $G_s(\cdot)$ is the capacity-gain function and $w_s$ incorporates the combined $\mathrm{CI}_s$ and $\mathrm{IRI}_s$ priority.

Sectoral sub-budgets $\Delta S_s \leq \phi_s \Delta S_{budget}$ prevent excessive allocation to sectors with low absorptive capacity. It should be noted that the budget is calculated from the above, and not set by financial rules.

### A1.7 Update Frequency and Governance

To maintain stability and transparency:

- Baselines ($\bar{X}_s$, $\sigma_{X_s}$) update annually.
- CI and IRI values update monthly or quarterly depending on data frequency.
- Weights update annually with parliamentary scrutiny.
- Input–output tables and Leontief matrices update annually or when new ONS releases become available.

This cadence ensures that short-run fluctuations do not trigger spurious constraint prioritisation while still allowing timely response to genuine structural stress.

## Appendix A2. Sector Coverage Overview

This appendix summarises the sectoral coverage used in constructing the Constraint Index (CI) and Inflation–Risk Index (IRI). The aim is not to provide an exhaustive taxonomy, but to set out the operational footprint of the UK economy as monitored by the National Constraint Board (NCB). The sector structure is illustrative and designed to be extensible: additional sectors or sub-sectors may be added as data availability improves, provided the core normalisation framework in Appendix A1 is maintained.

The sectors listed in this appendix represent the core operational footprint of the UK economy for the purposes of CI and IRI construction. The allocation and classification are illustrative and would be refined by the National Constraint Board (NCB) as data availability improves or new vulnerabilities emerge.

### A2.1 Sector-by-Sector Coverage

The Table below sets out the core sectors, the corresponding CI/IRI variables, and indicative data sources. It is illustrative rather than exhaustive; in practice the National Constraint Board (NCB) would refine this list and add further sectoral detail as required.

### A2.2 Notes on Interpretation

The variables $P_s$, $Q_s$, $L_s$, and $D_s$ are implemented in a sector-specific way while maintaining a common normalisation framework (see Appendix A1):

- In health, justice, and policing, $Q_s$ reflects service backlogs (waiting lists, case queues) rather than delivery times for goods.
- In construction and infrastructure, $Q_s$ reflects planning and project delays across the pipeline.
- In utilities, $Q_s$ captures outage, repair, and connection delays.
- $D_s$ always reflects external fragility and concentration, but the concrete indicators vary by sector (for example, import dependence for energy and food; platform dependence for ICT; supplier concentration in defence and pharmaceuticals).

This structure allows CDM to cover the whole economy with a consistent CI/IRI architecture, while respecting the operational differences between sectors.

| **Sector** | **Price** $P_s$ | **Queues** $Q_s$ | **Labour** $L_s$ | **Dependency** $D_s$ |
|---|---|---|---|---|
| Electricity & Grid | Wholesale prices | Connection backlog | Engineer shortages | Transformer imports; critical nodes |
| Gas & Fuel Supply | Energy indices | Delivery delays | Technician shortages | Import concentration; geopolitical risk |
| Housing & Construction | Build-cost indices | Planning & build delays | Trade shortages | Timber/ steel/ MMC imports |
| Commercial Property & Infrastructure | Construction indices | Project delays | Specialist labour gaps | Imported materials; large- contractor concentration |
| NHS (Elective Care) | Unit cost indices | RTT backlogs | Nursing/ clinical shortages | Imported devices & pharmaceuticals |
| Social Care | Care-cost indices | Unmet need indicators | Care worker shortages | Reliance on migrant labour; small-provider fragility |
| Education | Education-price indices | Class-size/ backlog proxies | Teacher shortages | IT/ textbook dependence |
| Policing | Policing cost indices | Case queues | Officer vacancies | Dependence on forensic labs/ICT |
| Justice System | Court cost indices | Trial backlogs | Judge/barrister shortages | Specialist IT/ platform dependence |
| Defence | Procurement indices | Maintenance/ refit delay | Engineer/ tech shortages | Foreign platform/ component reliance |
| Logistics & Trade | Freight indices | Port/ haulage delays | Driver/ warehouse shortages | Fuel & vehicle import exposure |
| Retail & Hospitality | CPI components | Delivery/ stock delays | Vacancy pressure | Import-heavy goods mix |
| Finance & ICT | Service-price indices | Project/ incident queues | Cyber/ software shortages | Semiconductor/ cloud dependence |
| Critical Inputs | Specialised input prices | Lead-time delays | Specialist labour gaps | Extreme import/ SPOF exposure |

## Appendix A3. Simulation Study: CDM vs Conventional Policy

This appendix provides a stylised macro-simulation illustrating how Constraint–Driven Macroeconomics (CDM) performs during a supply-side shock relative to conventional, deficit-targeting fiscal policy. The purpose is not to produce a forecast but to show the qualitative differences between the two policy regimes when confronted with an identical constraint-driven disturbance.

### A3.1 Simulation Overview

The simulation models a two-year horizon following a major supply shock (representing energy and logistics disruptions similar to those observed in 2021–22). It uses a simplified structural model with three core channels:

1. **Constraint pressures** measured through sectoral price, queue/lead-time, and labour-tightness indicators.
2. **Inflation pass-through**, calibrated using UK historical relationships between bottlenecked sectors and CPI spillovers.
3. **Throughput loss** due to binding constraints, using elasticities derived from input–output tables and observed UK productivity responses.

The conventional fiscal regime reacts primarily through interest-rate policy, with limited targeted fiscal intervention. The CDM regime instead deploys constraint-focused spending, fast-tracks regulatory actions, and uses precise demand-shifting tools in overstressed sectors.

### A3.2 Assumptions

The following stylised assumptions are used:

- A major external supply shock raises import and energy costs.
- Labour shortages intensify in already tight sectors (care, logistics, construction, energy).
- Under conventional policy, fiscal tightening and higher interest rates reduce demand but do not relieve the underlying bottlenecks.
- Under CDM, constraint relief is targeted to sectors showing the highest Constraint Index (CI) scores, combined with temporary demand-side adjustment in overheated sectors.
- The simulation spans 8 quarters.

These assumptions match empirical patterns documented in UK and OECD post-Covid inflation analyses.

### A3.3 Results

The comparative results are summarised in the table below. Values represent approximate magnitudes based on calibrated elasticities—not predictions, but illustrative outcomes highlighting the structural differences between the two policy approaches.

**Macro Simulation: CDM vs Conventional Fiscal Policy**

| Metric | Conventional Policy | CDM Response |
|---|---|---|
| Inflation peak | 8.5% | 5.2% |
| Output loss (2 years) | –3.4% GDP | –0.8% GDP |
| Employment loss | 220,000 | 40,000 |
| Grid backlog | +25% | +5% |
| Investment required | ~£12bn | ~£15bn |

### A3.4 Interpretation

Two effects drive the improved performance under CDM:

1. **Bottleneck relief lowers inflation at the source.** Targeting high-CI sectors reduces queue lengths, stabilises wages, and lowers price pressure before it spreads through supply chains.
2. **Throughput recovery is faster.** Regulatory fast-tracking, targeted labour programmes, and focused public investment return constrained sectors to normal flow conditions sooner, reducing the recessionary drag seen under blanket monetary tightening.

Thus, even though CDM may involve *more* targeted spending, its allocation and timing yield *less* inflation and *less* output loss than the conventional approach.

# Appendix A4. Governance Templates and Example Constraint Dashboard

### A4.1 National Constraint Board (NCB): Draft Terms of Reference

- **Mandate:** Identify, prioritise, and coordinate the relief of national real-resource constraints.
- **Reporting:** Quarterly Constraint Dashboard; Annual Constraint Audit.
- **Membership:** HM Treasury (Chair), Bank of England, ONS, NIC, DHSC, DfT, DESNZ, DLUHC, MoD, Home Office, DfE, devolved governments.
- **Decision Cycle:** Review data → approve top priority sectors → publish quarterly update → evaluate outcomes.
- **Transparency:** All datasets, methodology notes, and minutes published online.
- **Accountability:** Parliamentary scrutiny and independent academic advisory board.

### A4.2 Example Extract from a Constraint Dashboard

*Note: The full dashboard covers the sectors detailed in Appendix A2. The table below provides an illustrative extract using the same sector definitions.*

| Sector | CI | IRI | Priority | Primary Bottleneck / Status |
|---|---|---|---|---|
| Energy & Utilities | 1.72 | 1.41 | High | Transformer supply; grid-connection delays; domestic capacity expansion in progress (Q2). |
| Health & NHS Throughput | 1.15 | 1.08 | Medium | Specialist nursing shortages; elective backlog; modular theatres and training expansion underway (Q3). |
| Housing, Planning & Construction | 0.98 | 0.91 | Medium | Planning approvals throughput; skilled trades shortages; MMC pilot approved (Q3). |
| Transport & Logistics | 0.84 | 1.22 | Medium–High | Port congestion; HGV driver shortages; freight-route bottlenecks; logistics taskforce activated (Q2). |
| Agriculture & Food | 0.71 | 1.35 | Medium | Import dependence in fertiliser and feed; food-price volatility; resilience programme in development (Q4). |
| Digital, Telecoms & Data Infrastructure | 0.64 | 0.93 | Low–Medium | Network congestion in key regions; hardware import dependency; fibre acceleration programme (Q3). |
| Manufacturing & Industrial Production | 0.59 | 1.11 | Medium | Imported intermediate components; extended order backlogs; targeted credit guidance initiated (Q3). |
| Defence & Security | 0.53 | 1.17 | Medium | Procurement lead times; cyber-skill shortages; domestic supply-chain review initiated (Q3). |
| Local Government & Social Care | 0.48 | 0.66 | Low–Medium | Staffing shortages; backlog in SEND assessments; workforce plan in preparation (Q4). |
| Education & Skills | 0.44 | 0.52 | Low | Teacher vacancies; qualification bottlenecks; apprenticeship expansion underway (Q3). |

Sectors are ranked by $\mathrm{CI}_s$ and reviewed alongside their $\mathrm{IRI}_s$ values to identify the most binding constraints and the most systemically risky bottlenecks. Priority levels reflect both scores and the judged elasticity of capacity elevation.

## Appendix A5. Communications Toolkit

This appendix outlines a basic communications toolkit to support the implementation of Constraint-Driven Macroeconomics (CDM). The aim is to ensure that the technical framework described in the main text can be explained consistently and accessibly to non-specialist audiences without distorting its core ideas.

### A5.1 Objectives

The communications strategy for CDM has four main objectives:

1. To explain clearly that CDM is a *capacity-management system*, not a licence for unconstrained spending.
2. To shift public and policy discussion away from financial ratios (deficit, debt-to-GDP) and toward real constraints (labour, energy, materials, logistics).
3. To frame inflation as a *signal of real bottlenecks* and a guide to targeted intervention, rather than as an abstract monetary phenomenon.
4. To make the institutional mechanisms (National Constraint Board, dashboards, audits) visible and accountable to Parliament, media, and the public.

### A5.2 Core Messages

The following core messages are intended as a stable reference point for briefings, dashboards, and explanatory materials:

- **Money is a tool; capacity is the limit.** For a sovereign issuer, finance is not the binding constraint on public policy. The real constraint is available capacity: labour, energy, materials, and time.
- **Inflation is a signal of constraints.** Inflation emerges when spending presses against real bottlenecks. CDM uses inflation, and its decomposition, to locate those bottlenecks and guide investment.
- **We pick constraints, not winners.** The framework does not select particular firms or technologies. It prioritises sectors where capacity relief delivers the greatest reduction in inflation risk per pound spent.
- **Dashboards make trade-offs visible.** Publishing sectoral indices, priorities, and outcomes turns macroeconomic management from a closed technical exercise into an open, trackable governance process.

These messages should be reused consistently across all channels.

### A5.3 Audience-Specific Framings

Different audiences require different levels of detail and emphasis.

**Ministers and senior politicians.** Focus on:

- the practical problem CDM solves (supply-driven inflation, slow project delivery, visible bottlenecks);
- the fact that CDM provides a structured way to prioritise projects and defend those choices publicly;
- the role of dashboards and audits in supporting accountability.

Technical discussion of Leontief matrices and optimisation can remain in supporting material.

**Civil servants and technical officials.** Provide:

- formal definitions of $\mathrm{CI}_s$ and $\mathrm{IRI}_s$;
- documentation of data sources and update frequencies (Appendix A2);
- worked examples of constraint identification and programme design;
- clear interfaces between the NCB, Treasury, and line departments.

Here the emphasis is on reproducibility and integration with existing statistical systems.

**Media and general public.** Emphasise:

- concrete examples (for instance, grid connections, NHS backlogs, housing approvals);
- the idea that CDM targets *the bottlenecks that most people already experience* rather than abstract financial numbers;
- the visibility of progress through published dashboards.

Technical terms can be replaced with plain-language descriptions, while retaining links to the formal framework for those who want more detail.

### A5.4 Standard Communication Artefacts

The framework lends itself to a small number of standardised artefacts.

- **Two-page briefing note.** A short, non-technical summary of CDM, suitable for ministers, advisers, and external stakeholders. It should present the five focusing steps, the role of the NCB, and one or two concrete case studies.
- **Constraint Dashboard explainer.** A one-page guide to the quarterly dashboard, explaining how to read $\mathrm{CI}_s$, $\mathrm{IRI}_s$, and the priority ratings, and how they link to specific programmes.
- **Frequently Asked Questions (FAQ).** A structured set of questions and answers addressing common concerns such as: *Is this inflationary?*, *Does this ignore the deficit?*, *Is this picking winners?*, and *How is this different from traditional industrial policy?*
- **Technical annex for analysts.** A more detailed note for think-tanks, parliamentary committees, and economic journalists, summarising the construction of the indices, the use of input–output tables, and the allocation algorithm.
- **Slide deck.** A short set of slides that can be reused across departments and briefings, presenting the CDM architecture, example dashboards, and early results from pilot programmes.

### A5.5 Handling Common Objections

The following objections are likely and should be addressed consistently:

**"This is just a way to justify higher spending."** Response: CDM does not prescribe a particular size of the state. It changes *how* spending is targeted, not *how much* is spent. The fiscal envelope remains constrained by real resources and inflation targets; CDM allocates within that envelope to relieve the most important bottlenecks.

**"This ignores debt and the deficit."** Response: CDM does not deny that public debt exists. It states that, for a sovereign issuer, the operational constraint on new spending is not the mechanical level of the debt stock but the availability of real resources without generating unwanted inflation. Debt and deficit ratios may still be reported, but they are not used as primary control variables.

**“This is too complex for the public.”** Response: The underlying data and methods are technical, but the outputs are designed to be straightforward: a small number of sectors with high scores, a clear set of programmes aimed at relieving them, and regular reporting on whether waiting times, backlogs, and volatility are falling.

**“This will be captured by incumbents.”** Response: CDM focuses on constraints, not specific firms. Programmes are selected and evaluated on the basis of measured impacts on queues, prices, and capacity, not on the identity of beneficiaries. Publishing the indices, the weights, and the outcomes is central to limiting capture.

The purpose of this communications toolkit is not to replace the technical framework, but to ensure that it can be understood and scrutinised by the non-specialist audiences whose support is required for implementation.

## Appendix A6 Extended Rationale for Weight Selection

The weighting parameters $(\alpha, \beta, \gamma, \delta)$ encode the relative policy importance of price dynamics, queue or backlog pressure, labour tightness, and structural dependency risk in the construction of the Constraint Index. Unlike single-metric optimisation systems, CDM requires a weighting scheme that integrates empirical evidence, macroeconomic spillover channels, sectoral elasticity, and explicit democratic choice. This appendix sets out the full methodological rationale.

### A6.1 Economic Impact Sensitivity

Each component of the CI contributes differently to inflation and throughput loss. Historical ONS data, input–output tables, and supply-network shock simulations show that energy price spikes, for example, propagate more rapidly and widely than comparable shocks in other sectors. During such periods the NCB may increase $\alpha$ to weight price instability more heavily. Conversely, queues in high-elasticity service sectors may receive lower weighting when their macro effect is limited. These adjustments ensure that the CI reflects empirically observed macroeconomic transmission channels.

### A6.2 Systemic Fragility and Dependency Risk

The dependency term $(\delta D_s)$ captures risks that do not always manifest through prices or queues, yet have substantial national implications. High import concentration, reliance on a single foreign supplier, geographic chokepoints, or dependencies on rare materials may all indicate latent fragility. Even if $P_s$, $Q_s$, and $L_s$ remain stable, the systemic implications of such fragility justify higher weighting on $\delta$. This approach aligns with resilience frameworks developed by the OECD and national infrastructure bodies, recognising that structural risk requires proactive weighting rather than reactive correction.

### A6.3 Democratic Prioritisation

Where traditional macroeconomic frameworks embed value judgements implicitly within models, CDM makes these choices explicit and accountable. The weights are therefore subject to parliamentary review. Governments prioritising NHS throughput may elevate $\beta$ (queues) and $\gamma$ (labour tightness), whereas governments focused on energy security may increase $\delta$ to reflect the importance of reducing import dependence. This ensures that the CI's ranking of constraints aligns with articulated national objectives rather than technocratic defaults.

### A6.4 Sectoral Elasticity and Time-to-Impact

The expected effectiveness of fiscal action varies across sectors. Sectors with long training pipelines, slow permitting processes, or rigid capital cycles may yield limited near-term throughput gains despite high labour or queue pressure. In such cases the NCB may reduce $\gamma$ or $\beta$ for that sector to reflect lower short- run elasticity. Conversely, sectors with rapid time-to-impact—such as grid connections, modular construction, or elective-care throughput—may receive higher weighting because public investment generates capacity more quickly.

### A6.5 Calibration Procedure

The NCB follows a structured calibration procedure:

1. **Technical Baseline:** A recommended weighting set is generated from historical decomposition, regression analysis, and shock-propagation modelling.

2. **Risk & Resilience Adjustment:** Weights are adjusted according to the level of global volatility, supplier concentration, or known chokepoints (e.g. transformers, rare minerals, specialist labour).

3. **Democratic Oversight:** Parliament reviews the proposed weights. The trade-offs are made explicit (e.g. raising $\delta$ moves Energy/Grid ahead of Housing in CI ranking; raising $\beta$ prioritises NHS throughput over manufacturing).

4. **Sensitivity Analysis:** Alternative weighting configurations are tested and published in the Constraint Dashboard to illustrate robustness and allow public scrutiny.

### A6.6 Why Weighting Choices Matter

Weighting choices determine which sectors rise to the top of the priority list and therefore shape fiscal allocations, regulatory focus, skills planning, and credit guidance. Because CDM targets bottlenecks, not aggregate demand, incorrect or opaque weighting can misallocate resources or delay relief in critical systems. Publishing the weights makes these trade-offs visible and fosters institutional accountability.

### A6.7 Example of Weight Variants

During an energy-price shock:

$$(\alpha, \beta, \gamma, \delta) = (0.40,\ 0.20,\ 0.20,\ 0.20)$$

During an NHS backlog crisis:

$$(\alpha, \beta, \gamma, \delta) = (0.20,\ 0.35,\ 0.35,\ 0.10)$$

During a geopolitical supply-chain crisis:

$$(\alpha, \beta, \gamma, \delta) = (0.25,\ 0.15,\ 0.15,\ 0.45)$$

These configurations systematically alter the CI ranking and the resulting Constraint Budget allocations, demonstrating the importance of transparent and justifiable weighting methodology.

This appendix formalises the theoretical, empirical, and democratic basis for the weighting scheme and provides the level of methodological detail expected in academic evaluation and policy implementation.

## Appendix A7. Price–Propagation via the Leontief Inverse

This appendix illustrates how a price shock in one sector propagates through the economy using the standard Leontief-price system. Unlike the earlier stylised upper-triangular example, this example introduces realistic interdependencies: energy is an input into steel production, and both energy and steel are inputs into construction. As a result, an energy-price shock now affects downstream sectors.

### A7.1 Technical Coefficients

Let the (scaled) technical-coefficients matrix be:

$$A = \begin{pmatrix} 0.10 & 0.05 & 0.00 \\ 0.20 & 0.10 & 0.05 \\ 0.10 & 0.15 & 0.10 \end{pmatrix},$$

where entry $a_{ij}$ is the amount of output from sector $i$ used per unit of output in sector $j$. Thus:

- steel uses energy ($a_{\text{Energy, Steel}} = 0.20$),
- construction uses energy and steel ($a_{\text{Energy, Construction}} = 0.10$, $a_{\text{Steel, Construction}} = 0.15$),
- and all sectors use themselves to some extent via the diagonal.

### A7.2 Leontief Inverse

The Leontief inverse is:

$$L = (I - A)^{-1} = \begin{pmatrix} 1.13 & 0.09 & 0.01 \\ 0.27 & 1.14 & 0.08 \\ 0.17 & 0.19 & 1.13 \end{pmatrix}.$$

The entry $L_{ij}$ measures the total (direct + indirect) input from sector $i$ required to produce one unit of final output in sector $j$.

Here:

- $L_{\text{Steel, Energy}} = 0.27$ indicates that steel's cost structure is sensitive to energy inputs;
- $L_{\text{Energy, Construction}} = 0.17$ and $L_{\text{Steel, Construction}} = 0.19$ imply that construction costs are influenced by both upstream sectors.

### A7.3 Propagation of an Energy Price Shock

Suppose energy prices rise by 10%. The price-shock vector is:

$$\Delta P = \begin{pmatrix} 0.10 \\ 0 \\ 0 \end{pmatrix}.$$

The propagated price effects are:

$$\Delta \pi = L\,\Delta P = \begin{pmatrix} 1.13 & 0.09 & 0.01 \\ 0.27 & 1.14 & 0.08 \\ 0.17 & 0.19 & 1.13 \end{pmatrix} \begin{pmatrix} 0.10 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0.113 \\ 0.027 \\ 0.017 \end{pmatrix}.$$

Thus:

- energy prices rise by 11.3% (direct amplification from self-use),
- steel prices rise by 2.7% through energy-intensive production,
- construction prices rise by 1.7% through both steel and energy channels.

Even this small three-sector system demonstrates a key principle of constraint analysis: upstream volatility (here, in energy) produces measurable and structured downstream inflation depending on sectoral interlinkages. In realistic UK Input–Output matrices, these effects are far larger, particularly in electricity, gas, fertiliser, transport, steel, cement, and construction supply chains.

### A7.4 Link to the Constraint Index and Inflation–Risk Index

In the main text, the Constraint Index (CI) and Inflation–Risk Index (IRI) for sector $s$ are constructed from a small set of normalised indicators: prices, queues, labour tightness, and dependency:

$$\mathrm{CI}_s = \alpha\,\tilde{P}_s + \beta\,\tilde{Q}_s + \gamma\,\tilde{L}_s + \delta\,\tilde{D}_s, \qquad \mathrm{IRI}_s = w_p P_s + w_q Q_s + w_l L_s + \kappa D_s.$$

The Leontief-based price propagation in this appendix provides two distinct inputs into these indices:

1. **Contribution to the price component ($P_s$, $\tilde{P}_s$).**
   For a given upstream shock (here, a 10% increase in energy prices), the Leontief system yields a vector $\Delta\pi$ of implied unit-cost changes across sectors. Normalising these by

baseline prices gives a propagation- driven price signal:

$$P_s^{(\text{shock})} = \frac{\Delta \pi_s}{\pi_s^{\text{baseline}}}, \qquad \tilde{P}_s^{(\text{shock})} = \frac{P_s^{(\text{shock})} - \bar{P}_s}{\sigma_{P_s}}.$$

In the example above, a 10% energy shock produces approximately 2.7% higher steel prices and 1.7% higher construction prices. These contributions enter the CI and IRI as part of the sectoral price terms $P_s$ and $\tilde{P}_s$, signalling that a binding energy constraint would show up as sustained relative price pressure in downstream sectors.

2. **Information for the dependency/fragility component ($D_s$, $\tilde{D}_s$).**
The structure of the Leontief inverse $L$ also informs the dependency score $D_s$. Sectors whose outputs appear strongly in many rows of $L$ (that is, whose shocks propagate widely) are candidates for high strategic-criticality scores $SC_s$ within $D_s$. In the example, the fact that energy price shocks raise both steel and construction costs indicates that the energy sector has a materially higher propagation footprint than a purely local bottleneck would. This can be reflected in a higher $D_{\text{Energy}}$ and thus a higher $\text{IRI}_{\text{Energy}}$.

Operationally, the Leontief propagation analysis is therefore used in two ways: (i) to quantify how much of observed sectoral price pressure is traceable to specific upstream constraints, and (ii) to identify sectors whose position in the production network makes them disproportionately important for inflation risk. Both feed directly into the CI and IRI rankings that guide the Constraint Budget under CDM.

# Appendix A8 The $C_s$ contributors $P_s, Q_s, L_s, D_s$

## A8.1 $P_s$: Relative Price and Price Change

The $P_s$ indicator measures changes in **relative prices** between sectors. Inflation often begins with a constrained sector (such as energy or food), with prices rising there first before cascading into the wider economy. $P_s$ detects these early signals long before headline inflation peaks.

$P_s$ consists of three linked components: the Relative Price Index (RPI*), Short-Run Price Acceleration, and Price Volatility.

### A8.1a Relative Price Index (RPI*)

RPI* measures how much the price of a specific sector diverges from overall inflation.

$$\text{RPI}^* = \frac{\text{Sector Price Index}}{\text{Aggregate CPI or PPI}} \times 100$$

- **Unit:** Index (base year = 100)
- **Example:** If energy prices rise 30% while CPI rises 8%, then RPI$^*$ $\approx$ 120, meaning energy prices rose 20% faster than the national average.

### A8.1b Short-Run Price Acceleration ($\dot{P}$)

Short-run acceleration measures the month-on-month or quarter-on-quarter change in price inflation.

- **Unit:** Percentage points per month
- **Interpretation:** Rising acceleration indicates an early supply shock, even before headline inflation rises.

### A8.1c Price Volatility ($\sigma_P$)

Price volatility captures instability in supply and demand conditions. It is calculated as the standard deviation of price changes over a relevant period.

- **Unit:** Percentage (same units as price change)
- **Interpretation:** High volatility indicates unstable supply chains or chokepoints.

#### A8.1d Data Sources

- ONS CPI and PPI breakdowns
- BEIS/DESNZ energy price datasets
- DEFRA food price indices
- International freight indices (e.g. Drewry World Container Index)

### A8.2 $Q_s$: Queue, Lead Time and Backlog Indicators

The $Q_s$ indicator captures early operational signals that a system is approaching or has reached a capacity constraint. These signals typically appear *before* prices rise, making $Q_s$ an essential early-warning system within CDM.

$Q_s$ is a structured set of three indicators: Queue Length, Lead Time, and Backlog.

#### A8.2a Queue Length (Q)

Queues measure the number of tasks, transactions, or units of demand waiting in line for processing by a constrained resource.

- **Units:** Sector-specific (e.g. ships, patients, planning applications, trucks)
- **Examples:**
  - Ships waiting offshore at UK ports
  - Patients waiting for NHS treatment
  - Homes waiting for grid connection
  - Planning applications waiting approval

#### A8.2b Lead Time (L)

Lead time measures how long it takes for a request to be completed after entering the system.

- **Units:** Days, weeks, months, or years depending on the sector
- **Examples:**
  - NHS referral-to-treatment times (weeks)
  - Semiconductor delivery times (months)
  - Housing construction cycles (months/years)
  - Grid connection delays (years)

#### A8.2c Backlog (B)

The backlog represents the total volume of work already committed but not yet completed.

- **Units:** Number of items/tasks/cases/units
- **Examples:**
  - NHS elective surgery backlog
  - Grid connection backlog
  - Court case backlog
  - Manufacturing order backlog

#### A8.2d Data Sources

- NHS performance datasets
- Port authority queue statistics
- National Grid connection queue reports
- DLUHC planning and approvals data
- HMRC customs processing logs

### A8.3 $L_s$: Labour Tightness Indicators

The $L_s$ indicator measures labour market constraint pressure. Traditional metrics such as unemployment alone are insufficient; CDM uses multiple indicators to capture tightness, skill shortages, and wage dynamics more accurately.

$L_s$ consists of four primary components: Vacancy-to-Unemployment Ratio, Wage Acceleration, Sectoral Labour Stress Index, and Skill Shortage Intensity.

#### A8.3a Vacancy-to-Unemployment Ratio (V/U)

This ratio measures how tight the labour market is relative to available jobseekers.

$$\frac{V}{U} = \frac{\text{Vacancies}}{\text{Unemployed}}$$

- **Unit:** Ratio
- **Interpretation:**

  - $< 0.3$: Slack labour market
  - 0.3–0.7: Balanced
  - 0.7–1.0: Tight
  - $> 1.0$: Very tight (inflationary risk)

#### A8.3b Wage Acceleration ($\dot{W}$)

Wage acceleration measures the pace at which wage growth itself is increasing.

- **Unit:** Percentage points per month or year
- **Interpretation:** Rising wage acceleration indicates labour scarcity and potential inflation pressure.

#### A8.3c Sectoral Labour Stress Index (LSI)

The Labour Stress Index captures the degree of labour scarcity across multiple sectors.

- **Unit:** Index (0–100)
- **Components:**
  - Vacancy rates
  - Recruitment difficulty
  - Staff churn and turnover
  - Hard-to-fill roles
- **Examples:** High stress in NHS, logistics, construction, and energy engineering.

#### A8.3d Skill Shortage Intensity (SSI)

Skill Shortage Intensity measures the percentage of employers reporting difficulty filling roles due to skill gaps.

- **Unit:** Percentage (%)
- **Data Sources:** ONS Business Insights Survey, sector trade bodies, professional registries.

### A8.4 $D_s$: Import Dependency & Single-Point-of-Failure Exposure

The $D_s$ **indicator** measures how vulnerable a sector is to external resource constraints that can trigger supply-shock inflation, output loss, or cascading bottlenecks. $D_s$ captures two related but distinct dimensions: Import Dependency (ID%) and Single-Point-of-Failure Exposure (SPOF Score).

#### A8.4a Import Dependency (ID%)

Import dependency measures the share of a sector's critical inputs that must be imported.

- **Unit:** Percentage (%)
- **Data Sources:** ONS Supply–Use Tables, BEIS/DESNZ energy import data, HMRC trade statistics, DEFRA food security datasets, MHRA/WHO medicine supply data.

**Examples:**

- UK antibiotics: $\sim$ 90% import dependency
- Semiconductors: $\sim$ 100%
- Fertiliser: 70–80%
- Gas: 40–60%
- Timber: $\sim$ 80%

High import dependency increases vulnerability to global shocks, geopolitical tensions and freight disruptions.

#### A8.4b Single-Point-of-Failure Score (SPOF Score, 0–5)

The Single-Point-of-Failure Score measures the extent to which a supply chain depends on one critical chokepoint: a single supplier, country, factory, port, interconnector or material.

- **Unit:** Ordinal score (0–5)
- **Data:** UN Comtrade country concentration, ONS trade concentration, corporate supply-chain disclosures, DESNZ energy system reports, MHRA medicine source concentration, global market HHI data.

**Examples:**

- Antibiotics (China/India concentration): 5

| Score | Largest Supplier Share | Meaning |
|---|---|---|
| 0 | $< 10\%$ | Fully diversified |
| 1 | $< 30\%$ | Mild concentration |
| 2 | 30–60% | Noticeable concentration |
| 3 | 60–80% | Strong concentration |
| 4 | 80–95% | Critical dependence |
| 5 | 95–100% | Catastrophic dependence |

- Gas through European LNG chokepoints: 3–4
- Timber imports (Nordic/Baltic dependence): 3
- EV batteries (China/Korea): 4–5
- Solar panels (China): 5

**A8.4c Combined Fragility Score ($D_s$)**

CDM uses a simple combined fragility index:

$$D_s = \text{ID} \times (1 + \text{SPOF Score})$$

**Range:** 0–600

| $D_s$ Score | Interpretation |
|---|---|
| 0–50 | Low fragility |
| 50–150 | Medium fragility |
| 150–300 | Serious vulnerability |
| 300–450 | High fragility |
| 450–600 | Extreme strategic risk |

### A8.4d Sample UK $D_s$ Scores (Illustrative)

| Sector | ID% | SPOF | $D_s$ | Interpretation |
|---|---|---|---|---|
| Antibiotics | 90% | 5 | 540 | Extreme risk |
| Semiconductors | 100% | 5 | 600 | Extreme risk |
| Fertilisers | 75% | 4 | 375 | High fragility |
| Natural Gas | 40–60% | 3–4 | 160–300 | Serious–High |
| Transformers | 95% | 5 | 570 | Extreme risk |
| Timber | 80% | 3 | 320 | High fragility |
| EV Batteries | 90% | 4–5 | 450–540 | Extreme |
| Steel | 70% | 2 | 210 | Serious |
| Solar Panels | 85–90% | 5 | 510–540 | Extreme |
| Fruit | 80% | 1–2 | 160–240 | Serious |
| Vegetables | 45–50% | 2 | 135–150 | Medium–Serious |

### A8.4e Inflation Relevance

Sectors with high $D_s$ values are highly susceptible to:

- supply-shock inflation,
- shortages,
- long lead times,
- cascading bottlenecks across the wider economy.

$D_s$ therefore forms a core part of the CDM policy dashboard.

### A8.5 Summary of CDM Indicators

| Indicator | Subcomponents | Units | Purpose | Data Sources |
|---|---|---|---|---|
| $P_s$ | RPI*, Price Acceleration, Volatility | Index, %, $\sigma$ | Early detection of sectoral inflation | ONS CPI/PPI, BEIS, DEFRA |
| $Q_s$ | Queue, Lead Time, Backlog | Sector-specific | Early warning of bottlenecks | NHS, ports, grid, planning, customs |
| $L_s$ | V/U Ratio, Wage Acceleration, LSI, SSI | Ratio, %, Index | Labour constraint detection | ONS LFS, vacancy data, employer surveys |
| $D_s$ | Import Dependency, SPOF Score | %, 0–5 | Supply fragility and shock exposure | ONS, HMRC, WHO, UN Comtrade |

# Appendix A9 Constraint-Driven Macroeconomics Dashboard (Illustrative)

## A9.1 Resource Constraints (R)

| Sector | Utilisation | Lead Time | Backlog | Risk |
|---|---|---|---|---|
| NHS Elective Care | 95% | 34 weeks | 7.8m | High |
| Construction | 88% | 19 weeks | Rising | Medium |
| Grid Connections | 100% | 3–15 years | Severe | Critical |
| Wind Turbines | 78% | 4 months | Stable | Low |

## A9.2 Supply Fragility ($D_s$)

| Sector | ID% | SPOF | $D_s$ | Risk |
|---|---|---|---|---|
| Medicines | 90% | 5 | 540 | Extreme |
| Fertilisers | 75% | 4 | 375 | High |
| Timber | 80% | 3 | 320 | High |
| EV Batteries | 90% | 4–5 | 450–540 | Extreme |
| Transformers | 95% | 5 | 570 | Extreme |

## A9.3 Inflation Early Warning (Q)

| Area | Queue | Lead Time | Backlog | Inflation Risk |
|---|---|---|---|---|
| Housing | 12 months | 24–36 months | Rising | Medium |
| Shipping | Moderate | 4–6 weeks | Stable | Low |
| Microchips | High | 20–30 weeks | Falling slowly | Medium |
| NHS Dentistry | Severe | 6–18 months | Rising fast | High |

# Appendix A10 ONS/Treasury Methodology Note for $D_s$

## A10.1 Purpose

The $D_s$ indicator measures the vulnerability of the UK economy to global supply chain disruptions. High $D_s$ scores indicate sectors where shortages or input price spikes are most likely to generate supply-shock inflation or threaten domestic output.

## A10.2 Import Dependency Method

$$\text{ID\%} = \frac{\text{Imports of critical inputs}}{\text{Total UK supply}} \times 100$$

Data sources: ONS Supply–Use Tables, HMRC Trade Statistics, DESNZ, DEFRA, MHRA, UN Comtrade.

## A10.3 Single-Point-of-Failure Method

| Score | Largest Supplier Share | Meaning |
|---|---|---|
| 0 | $< 10\%$ | Fully diversified |
| 1 | $< 30\%$ | Mild concentration |
| 2 | 30–60% | Noticeable concentration |
| 3 | 60–80% | Strong concentration |
| 4 | 80–95% | Critical dependence |
| 5 | 95–100% | Catastrophic dependence |

## A10.4 $D_s$ Formula

$$D_s = \text{ID} \times (1 + \text{SPOF Score})$$

Range: 0–600.

## A10.5 Publication Frequency

- Monthly headline $D_s$ index
- Quarterly sectoral breakdown
- Ad-hoc updates during global supply shocks

# Appendix A11 Novelty and Prior Art

## A11.1 Prior Art and Relation to Existing Literature

The framework proposed in this paper builds on three separate but partially connected strands of prior work:

**(1) Modern Monetary Theory and Monetary Sovereignty.** The operational view of sovereign currency issuance, consolidated government accounts, and the mechanics of tax-driven money are developed in the literature on Modern Monetary Theory (MMT). Key works include Wray (1998, 2012), Kelton (2020), Tymoigne and Wray (2013), and Mitchell, Wray and Watts (2019). This literature identifies the real-resource constraint as the only meaningful limit to sovereign spending, but does not provide a systematic method for *locating* or *ranking* those constraints.

**(2) The Theory of Constraints.** Goldratt's Theory of Constraints (TOC) and the associated focusing steps form the backbone of constraint identification in operations management. Prior art here includes the original Goldratt (1984, 1990) formulations, later extensions to multi-constraint environments, and applications to supply chains and project management. These models are typically applied at the firm or project level and do not incorporate macroeconomic tools such as input–output matrices or inflation diagnostics.

**(3) Inflation Decomposition and Supply-Side Inflation.** A growing empirical literature decomposes inflation into supply-side, sectoral, or shock components: Baqaee and Farhi (2022), di Giovanni et al. (2023), Amiti, Itskhoki and Konings (2022), and work by the Bank of England, ECB and IMF. While these studies quantify the sectoral origins of inflation, they do not provide an operational policy mechanism for *relieving* the relevant constraints.

**Contribution relative to prior art.** CDM differs from the above strands in three ways. First, it converts the real-resource constraint in MMT into an operational diagnostic via the CI, IRI and $D_s$ metrics. Second, it generalises TOC from micro-level bottleneck management to economy-level constraint governance. Third, it embeds inflation decomposition within a fiscal allocation rule that directs sovereign spending to the highest-impact constraints. No existing framework combines sovereign monetary operations, constraint identification, and inflation management into a single implementable governance model.

This section therefore clarifies that CDM is not a restatement of existing theories, but a synthesis of three lines of research into a unified operational framework with direct policy implications.

The conceptual foundation of *Constraint-Driven Macroeconomics (CDM)* rests on two established but previously unconnected bodies of theory: (1) **Modern Monetary Theory (MMT)**, which redefines fiscal capacity in terms of real-resource availability rather than financial balances; and (2) **The Theory of Constraints (ToC)**, which models throughput and bottlenecks in complex systems. While both traditions are well-developed in their respective domains, a review of existing literature reveals no prior publication that systematically integrates these frameworks into a unified macro-fiscal model.

**Existing Work in Related Fields** **Modern Monetary Theory.** The MMT literature, exemplified by works such as Wray (2015), Kelton (2020), Tymoigne (2021), and Mitchell et al. (2019), consistently argues that monetarily sovereign governments face no financial constraint on spending, only real-resource limits expressed through inflation. However, existing MMT models generally treat these constraints as aggregate and ex-post signals rather than operational inputs for fiscal targeting. None provide a quantitative method for identifying or ranking specific sectoral bottlenecks or for allocating spending in proportion to their capacity-gain potential.

**Theory of Constraints.** Goldratt's *Theory of Constraints* (1984–1990) and its successors in operations and systems engineering introduced the five focusing steps — identify, exploit, subordinate, elevate, repeat — as a means of maximising throughput by addressing the most binding constraint in a process. While subsequent literature (e.g., Rahman & Sadrieh 2016; Cox & Schleier 2010) extended ToC across supply chains and project management, applications remain at the micro- or meso-economic level. No published research applies the ToC methodology to national-scale fiscal policy or macroeconomic planning.

**Bottlenecks in Macroeconomics.** Macroeconomic studies of constraint propagation (e.g., Pichler & Farmer 2021; Inoue & Todo 2020) and recent analyses of Covid-era supply shocks (OECD 2022; IMF 2023) model how sectoral shortages transmit through input-output networks and contribute to inflation. These models demonstrate the empirical relevance of bottlenecks but do not connect them to sovereign fiscal operations or to dynamic prioritisation frameworks akin to ToC.

**Composite Indices and Dashboards.** Institutional frameworks such as the EU Joint Research Centre's composite indicator methodology, or the UK National Infrastructure Commission's performance dashboards, employ multi-indicator indices for policy monitoring. Yet these are descriptive tools; they lack the normative and allocative logic that CDM introduces through the **Constraint Index (CI)** and the optimisation of fiscal outlays across competing bottlenecks.

**Distinctive Contributions of Constraint-Driven Macroeconomics**

1. **Integration of Monetary Sovereignty and Throughput Logic.** CDM unites MMT's focus on real-resource limits with ToC's throughput optimisation, converting inflation control from an aggregate monetary task into a targeted capacity-management process.

2. **Operationalisation of Real-Resource Constraints.** The **Constraint Index (CI)** provides a quantitative measure of sectoral bottlenecks using normalised indicators of price pressure, backlog, labour tightness, and dependency risk — weighted $(\alpha, \beta, \gamma, \delta)$ according to policy priorities.

3. **Dynamic Fiscal-Targeting Algorithm.** The framework defines the sovereign "budget" as a **real-resource envelope**, allocating additional spending ($\Delta S_s$) by maximising expected capacity gain under sectoral sub-budgets ($\phi_s \Delta S_{\text{budget}}$). This shifts fiscal control from arbitrary deficit ceilings to dynamic throughput optimisation.

4. **Institutional and Governance Innovation.** CDM establishes a **National Constraint Board (NCB)** responsible for maintaining a public Constraint Dashboard, setting policy weights, and coordinating constraint relief — thereby embedding transparency and democratic oversight into macroeconomic management.

5. **Policy Communication Architecture.** The model links technical indicators to public understanding through dashboards, communication toolkits, and explicit framing of inflation as a capacity signal rather than a punishment mechanism.

**Conclusion on Novelty** Based on an extensive review of MMT literature, ToC research, and macro-network modelling, there appears to be **no prior work** that (i) applies the ToC focusing methodology to sovereign fiscal management, (ii) embeds it within an MMT understanding of monetary sovereignty, and (iii) operationalises it through a constraint index and resource-based fiscal envelope. *Constraint-Driven Macroeconomics* therefore represents a **novel synthesis** that advances both fields and establishes a testable, implementable framework for real-world economic governance.

The empirical and implementation agenda for CDM is therefore twofold. First, existing datasets (ONS, OBR, BoE, NIC, sector regulators) can be used to prototype and back-test the CI, IRI, and Ds indicators against recent shock episodes, comparing CDM-based allocations with actual policy responses. Second, pilot implementations—initially in one or two sectors such as energy and NHS elective care—can generate real-world evidence on whether constraint-focused fiscal targeting delivers lower inflation and higher throughput than ratio-driven or interest-rate-only approaches.

**A11.2 Statement of Novelty**

This paper makes three core contributions. First, it converts the Modern Monetary Theory view of sovereign spending and real-resource limits into an operational macroeconomic framework capable of *locating, ranking, and quantifying* constraints using the CI, IRI and $D_s$ metrics. Second, it extends the Theory of Constraints from firm-level operations management to economy-wide bottleneck governance, combining micro-style focusing steps with macro-scale data, input–output propagation, and inflation diagnostics. Third, it integrates these components into a unified fiscal allocation rule — the Constraint Budget — that directs sovereign spending to the sectors where it delivers the greatest inflation relief and throughput gain. No existing body of work synthesises sovereign monetary operations, constraint identification, and inflation management into a single implementable framework with clear institutional and governance structures.

These contributions establish CDM as a novel, distinct approach to fiscal and inflation policy, rather than an extension of existing MMT, TOC, or supply-shock literature taken in isolation.

## Appendix A11.3 Literature Review and References

### A11.3a Modern Monetary Theory: From Financial to Real Constraints

Modern Monetary Theory (MMT) reframes macroeconomic management around the operational realities of sovereign currency issuance. The tradition originates with **Abba P. Lerner's** (1943) concept of *Functional Finance*, which argued that government budgets should be guided by employment and price stability, not arbitrary fiscal ratios. Lerner's insights were later extended by the Post-Keynesian school and formalised by **Randall Wray** (2015), **William Mitchell**, **L. Randall Wray** and **Martin Watts** (2019), and popularised through public policy exposition by **Stephanie Kelton** (2020).

At its core, MMT distinguishes between nominal and real constraints. A monetarily sovereign government can always issue its own currency to purchase available resources, but inflation emerges once spending exceeds the economy's real capacity. **Warren Mosler** (2010) illustrated these mechanics in practical fiscal terms, emphasising that taxes and bond sales regulate aggregate demand rather than finance expenditure.

Empirical and theoretical developments within MMT have shown that the correct policy variable for fiscal sustainability is the *availability of real resources*—labour, energy, and productive capacity—not the size of the financial deficit (Kelton & Tcherneva, 2012; Mitchell et al., 2019). This paradigm provides the macro-level foundation for the present paper: money is not a constraint, but the *efficient use of real capacity* is.

### A11.3b The Theory of Constraints: Managing Bottlenecks in Complex Systems

The **Theory of Constraints (ToC)**, first articulated by **Eliyahu M. Goldratt** in *The Goal* (1984; rev. 1992) and *What Is This Thing Called Theory of Constraints?* (1990), introduced a structured approach to identifying and alleviating the limiting factor within any productive system. Goldratt proposed the now-canonical *Five Focusing Steps*: Identify, Exploit, Subordinate, Elevate, and Repeat.

Subsequent studies in operations and management science—such as **Mabin & Balderstone** (2003) and **Gupta & Boyd** (2008)—have verified ToC's effectiveness in improving throughput and organisational performance. ToC's emphasis on systemic optimisation aligns with the continuous-improvement traditions of **W. Edwards Deming** (1986) and with the learning-organisation perspective of **Peter Senge** (1990).

Within this literature, *throughput* is defined as the rate at which a system generates goal-units (usually revenue or output) through the utilisation of constrained resources. Inflation, in macroeconomic terms, can be interpreted as the signal that national throughput has reached one or more binding constraints—a conceptual bridge to MMT's interpretation of inflation as a real-resource limit.

#### A11.3c Bridging the Two Traditions

While MMT operates at the macro level—focusing on monetary sovereignty, fiscal capacity, and aggregate inflation dynamics—ToC functions at the micro and meso levels, managing production and organisational flow. The unification proposed in *Constraint-Driven Macroeconomics* extends ToC's focusing methodology to the entire national economy, treating inflation and resource bottlenecks as the macro equivalents of production constraints.

This synthesis draws philosophical support from systems theorists such as **Donella Meadows** (2008), who framed economies as feedback-driven networks of stocks and flows, and **Stafford Beer** (1972), whose Viable System Model demonstrated how adaptive management can stabilise complex organisations. By integrating these insights, Constraint-Driven Macroeconomics converts the insights of ToC into a macro-fiscal control system that operates within the MMT understanding of monetary operations.

#### A11.3d Contribution of the Present Paper

Existing macroeconomic frameworks often recognise capacity limits only ex post—after inflation has emerged. Conversely, ToC's focusing steps provide a forward-looking method to detect and relieve constraints before systemic inefficiency escalates. The contribution of this paper lies in formalising that connection: it operationalises MMT's real-resource principle through ToC's constraint-management logic, proposing an institutional architecture (National Constraint Board, Constraint Dashboard, Constraint Budget) that makes fiscal policy dynamically responsive to real-world bottlenecks.

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The above list identifies the core foundational texts upon which CDM integrates three distinct traditions: sovereign currency theory, constraint-based operations management, and modern inflation decomposition. These references are provided in addition to the full bibliography included at the end of the manuscript.


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