UNIVERSITY OF CAMBRIDGE
Faculty of Economics

CAMBRIDGE WORKING PAPERS IN ECONOMICS

Trade Shocks and the Transitional Dynamics of Markups

Justas Dainauskas

Povilas Lastauskas

Abstract

We show that U.S. trade protectionism shocks cause the cyclical component of the aggregate U.S. price markup to increase significantly over time. However, if trade barrier announcements are covered by the media, which may help form expectations about the future, we find that the aggregate U.S. price markup response is zero upon impact, if not negative, before it eventually rises. We develop a simple canonical model of trade adjustment dynamics driven by habits in consumer preferences that replicates these empirical responses and use it to quantify the welfare implications. In the model, firms cut markups preemptively in anticipation of future trade barriers by factoring in the time that it takes to wean addicted consumers off of imported varieties.

Reference Details

CWPE	2431
Published	12 June 2024
Key Words	Trade Adjustment Dynamics, Trade Protectionism, Announcements, Anticipation, Deep Habits, Welfare Gains from Trade.
JEL Codes	C11, C32, F13, F17, F62.
Website	www.econ.cam.ac.uk/cwpe

Trade Shocks and the Transitional Dynamics of Markups*

Justas Dainauskas†
Reed College

Povilas Lastauskas‡
Homerton College, University of Cambridge

Abstract

We show that U.S. trade protectionism shocks cause the cyclical component of the aggregate U.S. price markup to increase significantly over time. However, if trade barrier announcements are covered by the media, which may help form expectations about the future, we find that the aggregate U.S. price markup response is zero upon impact, if not negative, before it eventually rises. We develop a simple canonical model of trade adjustment dynamics driven by habits in consumer preferences that replicates these empirical responses and use it to quantify the welfare implications. In the model, firms cut markups preemptively in anticipation of future trade barriers by factoring in the time that it takes to wean addicted consumers off of imported varieties.

JEL Classification: C11, C32, F13, F17, F62.

Keywords: Trade Adjustment Dynamics; Trade Protectionism; Announcements; Anticipation; Deep Habits; Welfare Gains from Trade.

*For useful comments and discussions, we thank Elhanan Helpman, Morten Ravn, Dennis Novy, Michele Piffer, Francesco Pappadà, Jaanika Meriküll, Mustapha Douch, Ziran (Josh) Ding, Ignacio Marra de Artiñano, and Jason Campbell. We are also grateful for feedback from anonymous referees and participants at the EEA-ESEM Congress, WEAI Annual Conference, South-Eastern European Economic Research Workshop at Bank of Albania, Australasia Meeting of the Econometric Society, Baltic Economic Association's annual conference at SSE Riga, the 1st Baltic Central Banks' Invited Lecture Series, and the seminar at Bank of Lithuania. Disclaimer: Lastauskas gratefully acknowledges support from Iceland, Liechtenstein, and Norway through the EEA grants (project no. S-BMT-21-8 (LT08-2-LMT-K-01-073)) under a grant agreement with the Research Council of Lithuania (LMTLT).

†Reed College, 3203 SE Woodstock Blvd, Portland, OR 97202, USA, e-mail: justasd@reed.edu.

‡Homerton College, University of Cambridge, Cambridge, United Kingdom and International Monetary Fund, 700 19th Street N.W. Washington, DC 20431, USA, e-mail: p.lastauskas@trinity.cantab.net.

1 Introduction

> *"Trade isn't about goods. Trade is about information. Goods sit in the warehouse until information moves them."* ["Chanur's Legacy", C. J. Cherryh]

Trade protectionism is often framed as a policy that curbs domestic exposure to foreign competition by curtailing imports. In modern trade theory, this international redistribution of market power is anti-competitive – it increases domestic price markups. In turn, rising price markups ramp up the aggregate welfare loss that comes with trade barriers, which are reflected in a higher cost of living and/or fewer varieties available for consumption (Krugman (1979, 1980)). By now these comparative statics are well-understood and acknowledged, but so far much less is known about how price markups are influenced by expectations of impending trade policy actions and whether those expectations affect the overall trade adjustment dynamics and welfare.

Traditionally, shifts from trade to autarky are portrayed as instantaneous and unanticipated jumps between two different states of the economy: the before and the after (a.k.a. "MIT shocks"). But we believe that there are at least three reasons why accounting for the transitional dynamics may alter the welfare outcomes: (1) *anticipation* – trade deals often take months, if not years, to be negotiated, ratified, and signed into law (Moser & Rose (2012)), while the terms of the negotiations may be covered by the media, which may help form expectations about the future (Metiu (2021)); (2) *sequencing* – even when trade deals are eventually hammered out and the details are announced to the public, the actual changes in trade barriers may be phased in gradually (Chisik (2003), Khan & Khederlarian (2021)); and (3) *delayed substitution* – trade flows take time to fully adjust in response to trade shocks independent of sequencing (Alessandria et al. (2021), Boehm et al. (2023)). This could mean that markups may start to adjust in the run-up to the actual changes in trade barriers depending on the anticipated course of action. And it may take longer for the change in markups to fully materialize even after the new trade barriers are fully phased in.

The biggest challenge of estimating the transitional dynamic impact of trade barriers on markups is the limited availability of high-frequency firm-level data on markups, which are notoriously poorly measured. Specifically, prices and (marginal) costs are rarely observable simultaneously, the difference between which measures the markup. Existing work pioneered by De Loecker & Warzynski (2012) offers a promising framework for approximating markups at various disaggregation levels. However, the vast majority of markup data sources are either firm-level at low (i.e., annual) frequency, which is ill-suited to study transitional dynamics and anticipatory effects, or aggregate at higher (i.e., quarterly) frequency, which neglects potential markup variation across firm-level characteristics that may impact expectation formation. Markups are also likely to be endogenous to other macroeconomic factors. And trade shocks may impact not only markups, but also those other factors. The inferred markup response to trade shocks may therefore be amplified (or attenuated) and hastened (or delayed) if these potential interactions are not addressed carefully.

In light of all this, our paper offers a first stylized attempt to study the intricate relationship between trade barriers, markups, and expectations. To gain some elementary empirical insights, we focus on a quarterly frequency measure of aggregate price markups that we obtain from Nekarda & Ramey (2020), which we believe is suited to study anticipatory effects. We employ an identification scheme that: (i) extracts exogenous shifts in trade policy from announcements of *new* Temporary

Trade Barrier (TTB) investigations compiled by Metiu (2021); and (ii) exploits the timing and duration of institutional deliberations that we infer from historical narratives surrounding major shifts in trade policy catalogued by Caldara et al. (2020). TTB investigations fundamentally begin as a quasi-judiciary response to unfair trade practices, such as dumped or subsidized imports, a retaliation that is intrinsically independent of the overall state of the economy. But if TTB announcements do not receive widespread media coverage, we conjecture that they may go unnoticed by private agents. This allows us to identify the potentially differential impact of exogenous anticipated and unanticipated trade protectionist shocks on price markups and other macroeconomic factors. We infer these potential differences empirically by estimating a Bayesian Structural Vector Autoregression (SVAR). Choosing this particular methodology is guided by a unique advantage, which is that it applies a set of theoretically-plausible sign restrictions on impulse responses of confounding macroeconomic factors, a toolkit first introduced by Canova & de Nicolo (2003) and Uhlig (2005) in their related analyses of aggregate anticipatory fiscal policy effects.

We find that *unanticipated* exogenous bouts of trade protectionism in the United States (henceforth U.S.) lead to a robust and significant increase in the aggregate U.S. price markup upon impact. And it continues to rise in the cumulative sense for another 3-4 years until the full extent of the dynamic response eventuates. However, if the U.S. trade protectionist measures are *anticipated*, then on average the aggregate U.S. price markup falls upon impact before it eventually rises. The difference in the initial markup response then gives rise to a cumulative increase in markups that tends to be lower when trade protectionism is anticipated compared to analogous policy actions that come as a complete surprise. Our *prima facie* results thus suggest that managing private agent expectations about trade protectionism may lead to a reduction in the long-run welfare loss.

We are not aware of any existing economic theory that simultaneously reconciles: (a) why the transmission of trade shocks to markups may be delayed; and (b) why expectations about future trade shocks may influence the direction to which markups adjust upon hearing the announcement. To rationalize these new empirical stylized facts, we develop a simple canonical model of trade adjustment dynamics that closely matches our empirical findings. Our formal starting point is the ubiquitous "new" trade theory (Krugman (1979, 1980)), where firms are monopolistically-competitive and exhibit increasing returns to scale technology, but for simplicity and consistent with the aggregate nature of our empirical analysis, there is no heterogeneity in terms of productivity or expectations. As is standard in the modern trade theory, our model also features households with love-of-variety preferences and inelastic labor supply. But what makes our model different is that we augment consumer preferences with *deep habits* (Ravn et al. (2006, 2010)) with which individual consumption choices of varieties today are influenced by the past choices of the entire population (i.e., the "Joneses"). In equilibrium, trade protectionism in our model changes the relative price of the domestic and foreign varieties, but the initial impact on trade flows is subdued because "old habits die hard". As the time passes, individuals gradually "catch up with the Joneses" and substitute foreign varieties with domestic varieties (i.e., the delayed import substitution effect).

Habits featured in an otherwise standard trade model offers a very simple framework of rationalizing both (a) and (b). If firms are rational, they recognize that "Jonesing" causes demand for imports to persist for some time in spite of newly enforced trade barriers. In addition, if firms are patient and forward-looking, their optimal strategy is to adjust markups in a way that maximizes profits inter-temporally as opposed to just here and now. Based on this premise, we show that consistent with the empirical evidence, when the future demand for domestic varieties is expected to rise due to impending trade protectionism, firms charge a relatively lower markup today, build up addiction to their variety over time, and gradually increase markups and profitability over the long term when the market is ultimately seized from the foreign competitors. By contrast, if trade barriers tighten immediately, then consistent with the empirical evidence, markups rise, but gradually due to the habit-induced lags in demand adjustment. We further show that in theory, these temporary pro-competitive effects in anticipation of trade protectionism tend to decrease the cumulative welfare loss measured as foregone units of consumption, since it gets better before it gets worse. Conversely, if trade protectionism is an immediate surprise, then it only gets worse.

The rest of the paper is organized as follows. Section 2 provides a brief literature review. Section 3 describes the data, the empirical methodology, the identification scheme, and the empirical results. Section 4 presents the theoretical primitives, the canonical representation, the theoretical impulse responses, and the hypothetical welfare losses under a wide range of model parameterizations. Finally, Section 5 summarizes the key implications of our results and concludes.

2 Related Literature

2.1 Habits

To the best of our knowledge, we are the first to study trade adjustment dynamics driven by deep habits in consumer preferences. Habits are a useful analytical tool that are known to help replicate a wide range of empirical moments in macroeconomics (Ravn et al. (2006, 2010), Caldara et al. (2020)) and finance (Campbell & Deaton (1989), Abel (1990), Campbell & Cochrane (1999)). In fact, there is such a large number of applications of habit formation in macro-finance that Havranek et al. (2017) compile 597 estimates of habit intensities reported in 81 published journal articles. We make use of their compelling meta-estimates of habit intensity to parameterize our theoretical model. However, thus far habits receive little attention in the trade literature. Admittedly, the caveat of modelling habits is that in practice preferences are not directly observable. But there is a large body of empirical literature based on panel data of individuals that reveals significant associations between past choices of brands or consumption expenditure and consumer decisions going forward in time (see Chaloupka (1991), Naik & Moore (1996), Chintagunta et al. (2001), Carrasco et al. (2005), Alvarez-Cuadrado et al. (2016), Raval & Rosenbaum (2018)).

2.2 Expectations

Expectations and uncertainty about future trade policy is a buoyant line of research that goes all the way back to Staiger et al. (1994). With the advent of data on firm-level holdings of inventories, Alessandria et al. (2019), Novy & Taylor (2020), Khan & Khederlarian (2021), and Douch & Edwards (2021) show that a prominent channel through which anticipation and uncertainty affect trade are changes in the stockpiling of durable imported inputs. Handley & Limão (2017), Crowley et al. (2018, 2020), and Caldara et al. (2020) study the effects of shifts in trade policy uncertainty and find significant influence on investment, export participation decisions of the firms, and growth in trade flows. In contrast to the antecedents, we focus on identifying the impact of anticipated and unanticipated trade policy shocks on the economy-wide markups both theoretically and empirically.

2.3 Trade Adjustment Dynamics

It is now well-documented that trade flows are less elastic to trade shocks in the short-run than in the long-run (see Gallaway et al. (2003), Boehm et al. (2023)). Baldwin (1992) offers the first justification for trade adjustment dynamics by modelling neo-classical (human and physical) capital accumulation. More recently, Alessandria et al. (2021) extend the neo-classical model to a heterogeneous firm setting and build on the earlier work of Alessandria & Choi (2007) to assimilate the fact that firms decide whether to participate in exporting at the extensive margin and that investment gradually lowers the cost of export participation.

Bound by the aggregate nature of our empirical analysis, we propose an alternative theoretical mechanism of trade adjustment dynamics induced by habits in consumer preferences. Our proposed mechanism does not contradict the neo-classical channel, but instead complements the existing work in this area. There are two reasons why our approach is useful to consider. First, in general equilibrium, our model predicts a dynamic trade elasticity that is consistent with the empirical evidence, but without the added degree of complexity that comes with dynamic heterogeneous firm environments, important though they may generally be. In fact, the canonical version of our model features just four equations that fully and succinctly characterize the entirety of trade adjustment dynamics, which makes it simple and accessible. Second, because the standard capital accumulation mechanism introduces a type of dynamic *supply* elasticity, which stands in contrast to numerous frameworks in the modern trade literature – with or without firm heterogeneity – that typically hold all factors of production fixed. By contrast, our model predicts a dynamic *demand* elasticity in an endowment economy setup, which characterizes variable markups in a way that is in principal compatible with a wide class of modern trade theories with or without firm heterogeneity.

2.4 Markups

2.4.1 Trend vs Cycle

We focus on the *cyclical* (i.e., around the trend) adjustments of markups to trade shocks. This is distinct from the influential works of Autor et al. (2020), De Loecker et al. (2020), and Helpman & Niswonger (2022), who document an upward *trend* in markups over long periods of time, which tends to coincide with the observed timeline of globalisation. Our mechanism is also different from the recent work of Burstein et al. (2020), who predict heterogeneous markup pro- and counter-cyclicality depending on firm size in an oligopolistically-competitive setting.

2.4.2 Policy Impact

There is some early empirical evidence from trade liberalisations in Turkey, India, and other developing countries that consistent with our results document a significant decrease in markups (Levinsohn (1993), Chen et al. (2009)). However, De Loecker et al. (2016) show that trade liberalisations may in fact cause markups to increase depending on how markups are measured among other factors. We contribute to this discussion by studying the transitional dynamics of markups and anticipation of trade shocks. Our results suggest a potential reconciliation to this dichotomy. Specifically, if we extrapolate our results, we show that trade liberalisations are pro-competitive in the long-run independent of anticipation, which is consistent with the conventional wisdom. But we also find that the initial impact of trade liberalisation announcements covered by the media may in fact be anti-competitive, which echoes the outcomes in De Loecker et al. (2016).

2.4.3 Variability

There are several existing approaches of introducing variable markups that arise either from strategic complementarities among imperfectly-competitive firms and/or non-homothetic preferences (e.g. Atkeson & Burstein (2008), Melitz & Ottaviano (2008), Simonovska (2015), Arkolakis et al. (2018), Amiti et al. (2019) among many others). The common thread between these approaches is that absent of nominal rigidities they give rise to variable markups that are structurally static. That is, markups that are endogenous to *contemporaneous* (i.e., not lagged and not lead) values of other variables in the system, such as market shares or relative prices. Implicitly, this reflects the fact that firms in partial equilibrium do not factor in their expectations about the future when making pricing and output decisions at present. Markup adjustments in the general equilibrium of these settings may still be gradual and influenced by expectations if there are other sources of dynamics, such as firm entry and exit, capital accumulation, or investment in innovation of quality-enhancing technology (e.g. Bilbiie et al. (2019), Peters (2020)), but unlike our model, expectations and markups in those settings interact indirectly.

Markup variation stemming from habits is inherently different, because demand persistence induced by habits compels firms to factor in how the present pricing and output decisions affect their expected future sales. In fact, we show that in partial equilibrium, the optimal markup is inversely related to expected future sales, which is the only relationship that features expectations in our model. It therefore makes a difference in our model whether trade shocks are expected in advance or hit firms as a complete surprise. This special feature of the model is a new and testable implication in both structural and reduced-form settings. It also helps us easily quantify the anticipatory welfare effects of trade policy announcements in theory, because it singles out anticipation from all other sources of trade persistence with one parameter – the discount rate.

3 Empirical Evidence

3.1 Data Description

We use quarterly aggregate U.S. time series data over the period of 1988:Q2-2015:Q4 (see Table 3 in the Online Appendix for more details).[1] There are four key variables of interest in our

[1]Limited markup data availability presents a trade-off between the level of aggregation, frequency, and time coverage. Available sources of tentative industry- or firm-level data for prices, (marginal) costs, and markups are almost invariably recorded at annual frequency, which is ill-suited for our purposes since our goal is to study the cyclical aspects of trade adjustment dynamics and anticipatory effects of trade policy announcements. If we had access to high-frequency firm-level data on markups, we could shed more light on how different firm-level characteristics relate to potential heterogeneity of expectation formation, and whether the distribution of expectations influences markups and trade adjustment dynamics in the aggregate, which is a fruitful topic for future research. Therefore, our theoretical

analysis. First, we obtain measures of the aggregate U.S. price markup (MKP_t) from Nekarda & Ramey (2020).[2] Second, we use the import penetration ratio (IPR_t) measured as imports at constant prices relative to total domestic demand, changes in which capture the substitution between foreign and domestic varieties. The third variable is the real aggregate consumption (CON_t), which is an indicator of aggregate demand and welfare in our analysis. And fourth, a measure of trade protectionism (TPM_t), which we describe in more detail below. Unless otherwise stated, all time series are logged and de-trended using conventional methods.[3]

3.2 Methodology

We infer the transitional dynamics of markups following an *exogenous* surge in trade protectionism controlling for changes in the aggregate demand as well as relative demand for imported and domestically-sourced consumables. To implement this experiment, we use the following Structural Vector Autoregression (SVAR) to determine $\mathbf{y}_t = [\text{TPM}_t, \text{IPR}_t, \text{MKP}_t, \text{CON}_t]'$ simultaneously:

$$\mathbf{A}_0\mathbf{y}_t = \mathbf{A}_1\mathbf{y}_{t-1} + \mathbf{e}_t, \tag{3.1}$$

where $t = \{1, 2, ..., T\}$, $\mathbf{A}_0$ and $\mathbf{A}_1$ are $k \times k$ matrices of structural coefficients with $k = 4$, and $\mathbf{e}_t$ is a $k \times 1$ vector of structural errors with $\mathbb{E}[\mathbf{y}_{t-1}\mathbf{e}_t'] = \mathbf{0}_k$, $\mathbb{E}[\mathbf{e}_t\mathbf{e}_t'] = \mathbf{\Sigma}$, and $\mathbf{\Sigma}$ is a $k \times k$ structural shock variance-covariance matrix. For illustrative purposes, there is only one lag. There is no constant term, since all time series are de-trended. Now suppose $\mathbf{A}_0$ is invertible. Furthermore, let $\mathbf{A} := \mathbf{A}_0^{-1}\mathbf{A}_1$ denote the reduced-form coefficients and let $\mathbf{u}_t := \mathbf{A}_0^{-1}\mathbf{e}_t$ denote the reduced-form errors. Then following Fernández-Villaverde et al. (2007), if the eigenvalues of $\mathbf{A}$ are smaller than one in modulus, we can characterize the transitional dynamics by estimating a reduced-form VAR:

$$\mathbf{y}_t = \mathbf{A}\mathbf{y}_{t-1} + \mathbf{u}_t. \tag{3.2}$$

Hence, the matrix of the reduced-form coefficients $\mathbf{A}$ and the reduced-form shock variance covariance matrix $\mathbf{S} := \mathbb{E}[\mathbf{u}_t\mathbf{u}_t'] = \mathbf{A}_0^{-1}\mathbf{\Sigma}\mathbf{A}_0^{-1\prime}$ are generally unknown, but can be estimated.

3.3 Identification

The identification problem that we face is that the knowledge of $\mathbf{A}_0$, $\mathbf{A}_1$, and $\mathbf{\Sigma}$ are sufficient to compute $\mathbf{A}$ and $\mathbf{S}$, but the converse is not true. And in order to infer the counterfactual response of $\mathbf{y}_t$ to, say, a j'th element innovation in the structural shock vector $\mathbf{e}_t$, the system requires either: (i) a k^2 number of *exclusion* restrictions on $\mathbf{A}_0$ and $\mathbf{\Sigma}$ (e.g. Sims (1980)) or a long-run polynomial

model presented below represents each firm to be symmetrical in equilibrium, which makes it consistent with our empirical approach that studies the transitional dynamics of markups at the aggregate level.

[2] Nekarda & Ramey (2020) present several different measures of the price markup depending on the underlying assumptions about the production function. It is well-known that choosing a different underlying functional form may influences the cyclical behaviour of the markup. Therefore, we consider the most general measure that is based on a production function that features increasing returns to scale and reflects the presence of overhead costs, a feature that is part of our general version of the theoretical model. However, as a robustness check, we also considered the basic markup measure based on a simple Cobb-Douglas production function.

[3] The cyclical components are extracted using the linear projection approach of Hamilton (2018). As a robustness check, we also consider alternative de-trending methods, such as the one-sided HP filter (Meyer-Gohde (2010)) and the two-sided HP filter (Hodrick & Prescott (1997)), but find that the baseline results are qualitatively similar.

mapping to them (e.g. Blanchard & Quah (1989)) given the estimates of $\mathbf{A}$ and $\mathbf{S}$; or more generally (ii) that $\mathbf{A}$, $\mathbf{S}$, $\mathbf{A}_0$, $\mathbf{A}_1$, and $\mathbf{\Sigma}$ are estimated jointly conditional on satisfying a certain *set* of restrictions (e.g. Canova & de Nicolo (2003) and Uhlig (2005) among others). The simplest version of (i) involves normalising and orthogonalising $\mathbf{\Sigma}$ and assuming that $\mathbf{A}_0$ is lower-triangular (i.e., the *Cholesky* decomposition of $\mathbf{S}$).[4] But given the lower-triangular structure of $\mathbf{A}_0$, the order in which each variable enters vector $\mathbf{y}_t$ generally makes a difference. In some cases, the ordering can in principle be motivated by economic theory and timing in response to shocks.[5] However, imposing the lower-triangular structure on $\mathbf{A}_0$ is generally insufficient for our purposes.[6]

3.3.1 Sign Restrictions

To overcome the variable ordering problem, we follow the approach pioneered by Canova & de Nicolo (2003) and Uhlig (2005) and later expatiated by Granziera et al. (2018) and Arias et al. (2018, 2019) in a related context of aggregate anticipatory fiscal policy effect analysis. If we extrapolate the key intuition of their method and apply that to trade policy analysis, the impact of trade protectionist shocks may be interpreted more broadly than the outcome of exclusion restrictions on structural matrices $\mathbf{A}_0$ and $\mathbf{\Sigma}$. Instead, trade protectionist shocks may be identified from a set of well-defined reduced-form coefficients that generate specific structural responses in the system (e.g. positive/negative/zero response or no restrictions), which are specified so as to comply with some loosely defined notion of economic theory or other prior information. To fix ideas, we now provide a formal definition of what constitutes a trade protectionist shock in our system, which in many ways conforms to the conventional wisdom in the modern trade theory, which we later validate with our own theoretical model.

Definition 1 (Trade Protectionist Shock)**.** *Let* $\mathbf{y}_t^j$ *denote the* j*'th element of vector* $\mathbf{y}_t$ *and let* $\mathbf{e}_t^{\mathrm{TPM}}$ *denote the orthogonalized structural innovation to the trade policy variable in vector* $\mathbf{e}_t$ *at date* $t = \{1, 2, ..., T\}$*. If we then calculate the* j*'th generalized impulse response at time horizon* $h = \{0, 1, 2, ..., \mathcal{H}\}$ *as the conditional forecast of each variable following a trade protectionist*

[4]The only restrictions that the reduced-form VAR imposes on $\mathbf{A}_0$ is that $\mathbf{S} = \mathbf{A}_0^{-1}\mathbf{\Sigma}\mathbf{A}_0^{-1\prime}$. There are $k^2 + k(k+1)/2$ unknowns in this relationship, but only $k(k+1)/2$ knowns after estimating $\mathbf{S}$, since $\mathbf{\Sigma}$ and $\mathbf{S}$ are symmetrical with $k(k+1)/2$ distinct elements. This means that k^2 identification restrictions are required. To reduce the number of restrictions without loss of generality, we follow the common practice of normalising $\mathbf{\Sigma} = \mathbf{I}_k$, where $\mathbf{I}_k$ is the identity matrix. This implicitly assumes that the structural shocks $\mathbf{e}_t$ are uncorrelated and interact only through the endogenous response of variables in $\mathbf{y}_t$. These conditions provide us with $k(k+1)/2$ number of identification restrictions and leaves us with $k^2 - k(k+1)/2 = k(k-1)/2$ number of remaining identification restrictions. Assuming that $\mathbf{A}_0$ is lower-triangular would give us those remaining $k(k-1)/2$ restrictions, but not necessarily without loss of generality.

[5]For instance, Blanchard & Perotti (2002) identify shocks to government spending by ordering that variable first, which consistent with the federal budgeting infrequency assumes that fiscal policy only responds to shocks to all other variables in the system with a lag. Similarly, Bernanke & Blinder (1992) identify shocks to the federal funds rate by ordering that variable last, which assumes that monetary policy responds to shocks in all other variables contemporaneously, but all other variables in the system respond to monetary policy shocks only with a lag.

[6]Transitional dynamics of markups following shifts in trade policy are not yet well-documented and there is no consensus about how trade policy interacts with other confounding macroeconomic factors, not least because shifts in trade policy are in many ways irregular. Specifically, motives (i.e., discretionary or rules-based), scope (i.e., which industries are affected), and sequencing (i.e., how long it takes to enforce) vary on a case-by-case basis (e.g., trade liberalisations often take time (Moser & Rose (2012)), but sanctions may proceed rapidly (Bown (2021))). For instance, the "Nixon shock" of August 1971, which among other things resulted in a steep tariff increase on all U.S. imports, is as a deliberate policy response to rising inflation rate at the time. This suggests that TPM_t should be ordered last, such that it responds to shocks in other variables in the system contemporaneously, much like monetary policy conduct. By contrast, the sudden imposition of tariffs on steel and aluminium in March 2018 was a precautionary measure, whose aim was to ensure future national security, in which case ordering TPM_t first should be the appropriate choice.

shock, namely $\text{IRF}_h^j = \mathbb{E}_t[\mathbf{y}_{t+h}^j | \mathbf{e}_t^{\text{TPM}} = 1] - \mathbb{E}_t[\mathbf{y}_{t+h}^j | \mathbf{e}_t^{\text{TPM}} = 0]$, *then we conclude that the trade protectionist shock itself is set-identified provided it satisfies the following set of sign restrictions:*

$$\text{IRF}_h^{\text{TPM}} > 0, \qquad \text{IRF}_h^{\text{IPR}} < 0, \qquad \text{IRF}_h^{\text{CON}} < 0, \qquad \text{for} \qquad h = \{0, 1, ..., \mathcal{H}\}, \tag{3.3}$$

which leaves $\text{IRF}_h^{\text{MKP}}$ *unrestricted.*[7]

According to this definition, when a trade protectionist shock ($\text{IRF}_h^{\text{TPM}} > 0$) hits the economy, then irrespective of how markups ($\text{IRF}_h^{\text{MKP}}$) respond, the economy substitutes away from consuming imports ($\text{IRF}_h^{\text{IPR}} < 0$) and consumes less overall ($\text{IRF}_h^{\text{CON}}$) for at least $\mathcal{H} \geq 0$ consecutive periods. This is what happens in general equilibrium in a wide-class of models pertaining to the modern trade theory (see Arkolakis et al. (2012)). The key advantage of defining trade protectionist shocks in this particular way is that we are able to infer the transitional dynamics of markups ($\text{IRF}_h^{\text{MKP}}$) without any preconceived notion of theory about markups. We could in principle incorporate many more additional restrictions on the timing and on the response of markups, but leaving markups unrestricted is a way of remaining deliberately agnostic and letting the data speak for itself.[8] This would not be the case if we simply assumed that $\mathbf{A}_0$ is lower-triangular, because that would inherit any chosen variable ordering, which then embeds implicit preconceptions about which structural shocks in the system affect markups directly upon impact and which do not.

3.3.2 Foresight Problem

If new trade policy measures are announced to the private agents well before those measures are actually enforced, anticipation of those policy actions in advance may induce an endogenous markup response ahead of time that is potentially different to the one where private agents are given no time to make preparations. This poses a *foresight* problem (Ramey (2016)), which creates additional challenges to, but also opportunities for, identification. Neither the variable ordering nor the sign restrictions alone that we implement contain sufficient information to distinguish and compare the structural responses of markups to what may be thought of as anticipated and unanticipated trade protectionist shocks from the perspective of private agents. Instead, to achieve such identification, we adopt the following three-step approach:

1. **Narrative.** In addition to the above sign restrictions, we define trade protectionism measures TPM_t as a the dollar value of all *newly* announced Temporary Trade Barrier (TTB) investigations, a time series that we obtain from Metiu (2021).[9] The TTB investigation variable

[7]In a traditional SVAR with lower-triangular $\mathbf{A}_0$ and normalized $\mathbf{\Sigma} = \mathbf{I}_k$, the impulse responses are point-identified, since they are conditional on the point estimates of $\{\mathbf{A}, \mathbf{S}\}$, such that $\mathbf{A}_1$ can be recovered from $\mathbf{A}_0$ and $\mathbf{A}$, whereas $\mathbf{A}_0$ can be recovered from $\mathbf{S}$. However, the impulse responses from the sign-restricted SVAR are set-identified, since they merely impose joint inequality restrictions on the structural responses that must be satisfied by the elements of $\mathbf{A}$ and $\mathbf{S}$. To characterize these restrictions in the context of the TTB announcements and the event-based identification strategy, we adopt Bayesian algorithms formalized by Rubio-Ramírez et al. (2010) and Binning (2013) and implement them using `Matlab` packages developed by Canova & Ferroni (2021).

[8]The cyclical component of markups may in principal be correlated with the cyclical component of consumption due to non-homotheticities. As a robustness check in Section 3.4.2, we also consider leaving both markups ($\text{IRF}_h^{\text{MKP}}$) and consumption ($\text{IRF}_h^{\text{CON}}$) unrestricted, but we find that the inferred baseline results remain practically unchanged.

[9]Metiu (2021) constructs TTB measures in four distinct steps. First, using micro-level data on anti-dumping, countervailing duties, and safeguards obtained from the U.S. government authorities, the author identifies which products and at what date the government opens up an investigation. Second, the count of products subject to the

is by construction orthogonal to all trade protectionist measures announced in the past and moreover the actual outcomes of the TTB investigations are in many ways exogenous to the state of the economy, because they depend on the quasi-judicial investigation into whether U.S. industry is suffering "material injury" from "unfair" trade practices.

2. **Media Coverage.** We conjecture that TTB investigations, which typically last somewhere between 12-18 months, may go unnoticed by the private agents if they receive limited media coverage. The first step in our definition of *anticipated* shocks to the trade protectionism measures TPM_t is therefore to make use of similar time series also compiled by Metiu (2021) that re-weighs the dollar value of TTB announcements by the intensity of media coverage. That way more importance is given to the TTB investigations that are widely broadcasted, since that may help private agents form expectations about the future of the economy.[10]

3. **Events.** To fully capture historical episodes of looming trade protectionism that may even go beyond the scale of TTB investigations, we construct and incorporate auxiliary dummy variable "event" time series (EVT_t) into the system *à la* expectations-augmented VAR of Perotti (2011) and Ramey (2016)).[11] In constructing the anticipated event ($\mathrm{EVT}_t^{\mathrm{ANT}}$) and unanticipated event ($\mathrm{EVT}_t^{\mathrm{UNA}}$) time series, we refer to the catalogue of trade policy instances in the Trade Policy Uncertainty (TPU) Database compiled by Caldara et al. (2020). Together with historical records sourced from media outlets, we then determine whether: (1) each listed event is anticipated (i.e., announced, but not necessarily yet implemented) or unanticipated (i.e., announced and implemented within the same quarter); and (2) whether those events refer to trade protectionism, as opposed to liberalisation, since our identification applies only to the introduction of new trade barriers, not the suspension of existing trade barriers (see Table 4 in the Online Appendix for further details).

newly initiated TTB investigations is linked to the product-level data on trade flows. This produces a time series for the value of U.S. imports from all trade partners facing TTB investigations at constant prices. Third, because more TTB investigations are generally filed during recessions when firms are struggling than expansions, the TTB series is regressed on a comprehensive set of macroeconomic factors in order to orthogonalize the exogenous variation in TTB actions from to the cyclical variation and/or confounding factors. And (optionally) fourth, the U.S. dollar value of TTB residuals are re-weighted by the intensity of media coverage from different sources, such as those collected from news reports, editorials, and opinion pieces that contain direct references to TTB investigations.

[10] The potential threat to identification is that announcements that receive the most media attention may be the most rapidly enforced trade protectionist measures, which gives less time for private agents to influence the economy by acting on their expectations. Note that the correlation coefficient between the news-trade-weighted and trade-weighted TTB announcement series is relatively high (0.77), which indicates that the TTB cases that affect a larger share of the U.S. imports tend to receive more attention from the press independent of how long the investigations last. The most notable instance of TTB investigations widely broadcasted by the media is 2001:Q2, which involved a wide range of steel imports (95 product categories) worth upwards of 20bn U.S. dollars (see Fig.2 in Metiu (2021)), which in 2002:Q1 (i.e., 3 quarters later) resulted in steep tariff increases up to 30% imposed by the Bush administration. But a counterexample is the 1989:Q2 TTB investigations into Canadian limousine imports amounting to some 14.5bn U.S. dollars (i.e., second-largest in the sample) that received very little media coverage. Subsequently in 1990:Q1 (i.e., 3 quarters later once again) this resulted in a suspended liquidation of imports following the affirmatives and anti-dumping determinations given by the International Trade Administration (ITA) of the Department of Commerce and the United States International Trade Commission (USITC). This shows that the two largest instances of TTB investigations in the sample – one with and another without media attention – were ultimately enforced at roughly the same time after the initial announcement was made, which provides some reassurance for our identification strategy.

[11] As explained by Ramey (2016), we cannot resort to a proxy VAR as in Mertens & Ravn (2014) due to the foresight-driven non-fundamental moving average representation, which invalidates the interpretation of the VAR residuals as prediction errors and disables the use of a proxy (e.g. event variable) as an instrument projected onto the reduced-form residuals. For the precise conditions on the instrument in the partially-identified VAR, in addition to the shock of interest being invertible, refer to Plagborg-Møller & Wolf (2022) and Miranda-Agrippino & Ricco (2023).

In short, we infer the transitional dynamics following trade protectionist shocks by inducing structural innovations to the corresponding event time series ($\text{EVT}_t^{\text{ANT}}$ or $\text{EVT}_t^{\text{UNA}}$), which together with TTB_t (or the news-weighted TTB_t, namely TTBN_t) supersede the trade protectionism measures TPM_t, but retain analogous sign restrictions (i.e., $\text{IRF}_h^{\text{TTB(N)}} > 0$ and $\text{IRF}_h^{\text{EVT}} > 0$).

3.4 Results

3.4.1 Baseline

Figure 1 plots the estimated impulse responses following anticipated and unanticipated trade protectionist shocks as defined above equal to the estimated size of one standard deviation. Our estimates suggest that both anticipated and unanticipated trade protectionist shocks are well-identified given that TTB(N) and EVT increase significantly, while IPR and CON fall significantly for 2 consecutive time periods (i.e., 0th and 1st), which is consistent with the set of sign restrictions that constitute a trade protectionist shock according to our definition. Conditional on these responses, we find that MKP rises significantly upon impact, but only if the shock is unanticipated. However, if the shock is anticipated, then the median MKP response upon impact is negative, but not significantly different from zero, and it takes further 4 quarters (i.e., one year) after the shock occurs for MKP to actually start increasing significantly in a statistical sense.

The median cumulative increase in markups after 12 quarters (i.e., three years) is 0.033 (i.e., 3.3%) if the shock is unanticipated, but only 0.029 (i.e., 2.9%) if the shock is anticipated, which is a small, but notable discrepancy. We also find that at that time horizon, the unanticipated shocks to EVT (TTB(N)) contribute 1.07% (8.14%) share to the forecast error variance of MKP compared to 1.55% (15.96%) if the shock is anticipated. The forecast error variance shares for CON with unanticipated and anticipated shocks account for 2-3% due to EVT and around 6% due to TTB(N).

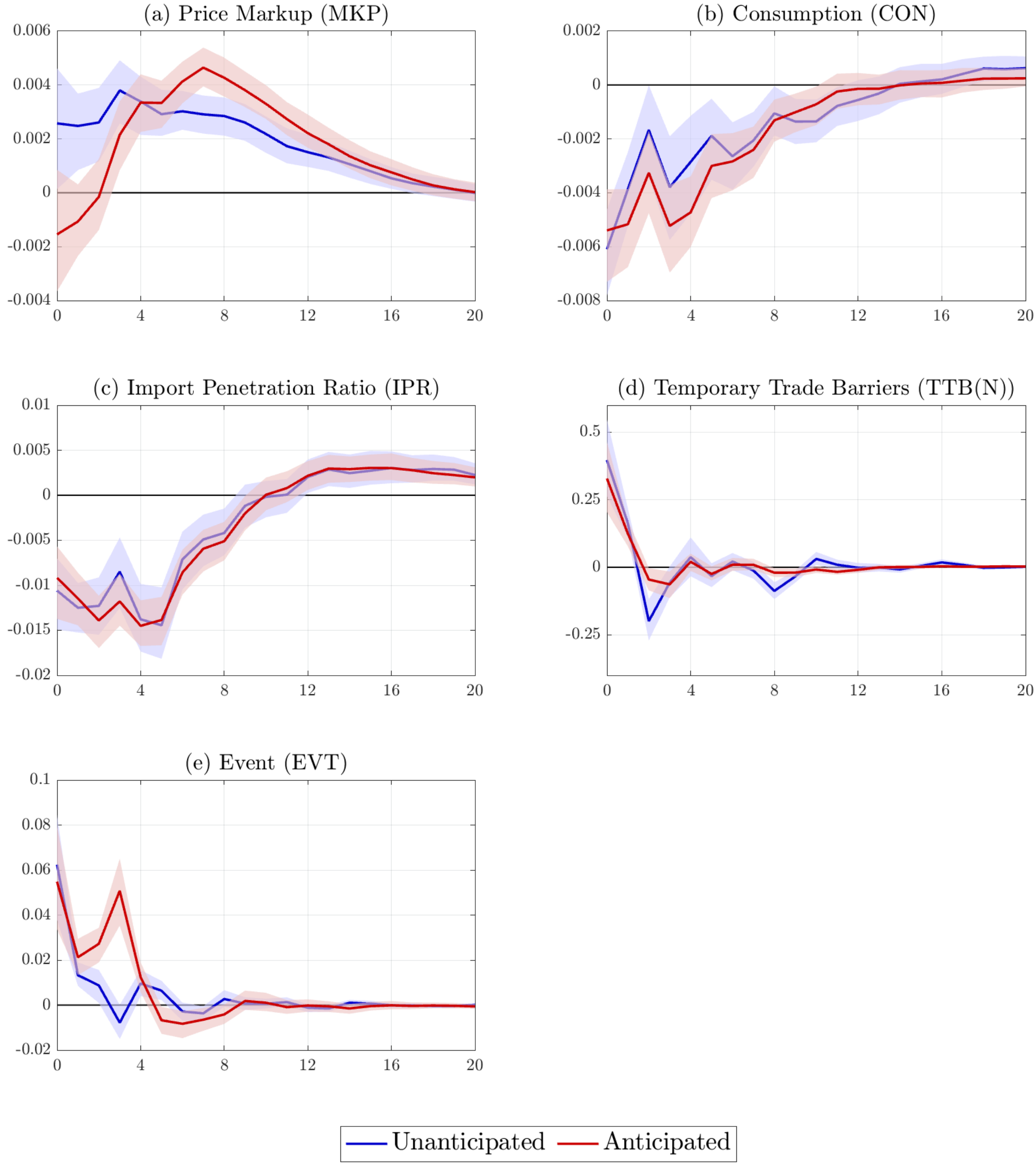
3.4.2 Robustness Analysis

We assess the robustness of our baseline results by conducting a number of additional experiments:

(i) Fewer Sign Restrictions: one concern is that markups may be pro- or counter-cyclical depending on firm size, the level of aggregation in the non-firm-level data, and other measurement factors (see Jaimovich & Floetotto (2008), Burstein et al. (2020) among others). Since we impose a negative sign restriction on the impulse response of aggregate consumption, namely $\text{IRF}_h^{\text{CON}} < 0$, which is positively correlated with output, that may inadvertently generate a significant markup response that is not entirely agnostic. To address this concern, we re-estimate impulse responses without placing any restrictions on $\text{IRF}_h^{\text{CON}}$ leaving all else exactly as the same as the baseline (i.e., exclude $\text{IRF}_h^{\text{CON}} < 0$ from Definition 1). We find that the impulse responses for all variables turn out to be practically unchanged both qualitatively and quantitatively, except as expected, the impulse responses of consumption initially exhibit somewhat more statistical uncertainty (see Figure 5 in the Online Appendix).

(ii) No Narratives / Only Sign Restrictions: another interesting experiment is to employ a standard measure of import competition, namely the aggregate import tariff as a percentage of total imports (TRF_t). It measures the effective protection of imported goods and is calculated as

Figure 1: Non-Cumulative Impulse Responses to Anticipated and Unanticipated Trade Protectionist Shocks Identified using Sign Restrictions, Historical Events, Media Coverage, and Temporary Trade Barrier Announcements



The vertical axis measures the sign-restricted *non-cumulative* impulse responses in terms of log changes in the cyclical component (except for dummy variable EVT and TTB(N)). The horizontal axis measures the time horizon $h = \{0, 1, 2, \ldots\}$. The standardized residuals of the TTB induced trade value and news-weighted trade value series adjusted for serial correlation come directly from Metiu (2021) and are not logged or de-trended. The cyclical components of all other time series are obtained using the Hamilton (2018) filter. The results are based on the Bayesian SVAR model with a lag order of 4 quarters and sign restrictions on TTB induced trade value and news-weighted trade value, IPR, and consumption that hold for two consecutive quarters after the shock (i.e., $\mathcal{H} = 1$). Solid lines are the point-wise posterior medians. The shaded areas outline the 68-percent credible sets, which is standard in Bayesian econometrics. Each figure is based on 1000 independent draws of parameters from posterior distributions.

the ratio of customs duties over imports less customs duties. We use the cyclical component of this measure instead of the temporary trade barriers shock, and apply the same sign restrictions as before (see Figure 6 in the Online Appendix). This setup is deliberately flawed due to the potentially endogenous nature of import tariffs to the state of the economy as well as being subject to the aforementioned foresight problem, not to mention the fact that it does not distinguish between anticipated or unanticipated trade protectionist shocks. However, despite all these caveats, we still find that markups increase significantly in the long-run, but there is a lot of uncertainty surrounding the initial markup response.

(iii) Consumable vs Industrial Imports:[12] though we do not have access to disaggregate data on markups at quarterly frequency, we check whether our baseline findings still go through if we instead replace the aggregate import penetration ratio (IPR_t) with one that measures the import penetration ratio for consumption goods $IPRC_t$ or, alternatively, for industrial supplies and materials $IPRI_t$ (see Figures 7 and 8 in the Online Appendix). This extension attempts to shed some light on the theoretical mechanism in our model presented below. Our theory emphasizes the role of consumption habits, which in principal may be more pervasive for consumable varieties.

We find that replacing IPR with IPRC or IPRI leads to a similar gradual and significant increase in MKP following both anticipated and unanticipated trade shocks. However, the significant increase in MKP following unanticipated shocks that occurs in our baseline results becomes on average more subdued and surrounded by more uncertainty in the case of both IPRC and IPRI. This suggests that the composition of the import penetration ratios can make a difference for the inferred transitional dynamics of markups even if trade protectionist shocks are identified in the exact same way. However, this does not necessarily invalidate our proposed theoretical mechanism of consumption habits. First, because it is conceivable that some industrial supplies and materials enter individual consumption baskets in practice (e.g. DIY home production). And secondly, because as we later show in our theoretical model, where consumable imports take the centre stage, the difference between the markup response to anticipated and unanticipated trade shocks diminishes when trade shocks become phased-in more gradually, which is not something that our identification scheme controls for empirically. And because the timing and the incidence of trade barriers in our sample still aggregates across consumable and industrial imports, the unobserved variation in the sequencing of trade shocks that potentially impacts different sets of goods with different timing may be a relevant factor when drawing more disaggregate inference.

(iv) Other: we have also considered several alternative measures of price markups compiled by Nekarda & Ramey (2020), we explored whether our results are robust to different filtering techniques, such as one- or two-sided HP filters, and other sign restriction strategies that may involve zeros upon impact. For the sake of space, we do not display or discuss the details of all other alternatives, but we find that the bulk of these results square well with the outcomes of our chosen baseline specification.

[12] We are grateful to Elhanan Helpman for this idea.

4 Theoretical Model

Consider two countries: home (H) and foreign (F). They trade final goods and services with each other and evolve over discrete time $t = \{1, 2, ...\}$. All foreign variables are henceforth denoted with an asterisk "$*$". Each country is populated by a continuum of households indexed by $\psi \in [0, \Psi + \Psi^*]$, where $\Psi, \Psi^* > 0$ is the population mass in each country. There is a continuum of varieties produced by monopolistically-competitive firms indexed by $\omega \in [0, \Omega + \Omega^*]$ with $\Omega, \Omega^* > 0$. To conserve space and unless otherwise stated, we present the structure of the economy from the perspective of home and assume that analogous structure applies to the foreign country.

4.1 Preferences

Households derive utility from consumption of both home and foreign varieties. Preferences are characterized as the Dixit & Stiglitz (1977) Constant Elasticity of Substitution (CES) aggregator augmented by consumption history as in Ravn et al. (2006). At home this is given by

$$C_t(\psi) = \left[\int_0^{\Omega} C_{H,t}(\psi, \omega)^{1-1/\eta} d\omega + \int_0^{\Omega^*} C_{F,t}(\psi, \omega)^{1-1/\eta} d\omega \right]^{1/(1-1/\eta)}, \tag{4.1}$$

$$C_{H,t}(\psi, \omega) = X_{H,t}(\psi, \omega) X_{H,t-1}(\omega)^{\theta}, \quad \text{and} \quad C_{F,t}(\psi, \omega) = X_{F,t}(\psi, \omega) X_{F,t-1}(\omega)^{\theta}, \tag{4.2}$$

where $C_t(\psi) > 0$ is the real consumption of home household $\psi \in [0, \Psi]$, $\eta > 1$ is the "*Armington*" elasticity of substitution, $\{X_{H,t}(\psi, \omega), X_{F,t}(\psi, \omega)\}$ measures the consumption of variety ω from country $\{H, F\}$ by individual ψ at date t, $\{X_{H,t-1}(\omega), X_{F,t-1}(\omega)\}$ is the corresponding consumption history, and $\theta \geq 0$ is a constant. Preferences exhibit two properties: (i) love-of-variety or concavity if $\eta > 0$, such that $C_t(\psi)$ is increasing in Ω and Ω^*; and (ii) deep habits if $\theta > 0$, such that $C_t(\psi)$ is increasing in $\{X_{H,t-1}(\omega), X_{F,t-1}(\omega)\}$. The consumption history $\{X_{H,t-1}(\omega), X_{F,t-1}(\omega)\}$ is specific to each variety, not just specific to the country as a whole, thereby distinguishing the "deep" habit framework from other existing models of "shallow" habits that are applied to aggregate quantities.

4.2 Technology

Following Krugman (1979, 1980), monopolistically-competitive firms incur fixed costs of production and require labor as the sole factor of production. This is embedded in the following linear production technology with increasing returns to scale:

$$X_{H,t}(\omega) = \begin{cases} \phi[L_{H,t}(\omega) - \alpha] & \text{if} \quad L_{H,t}(\omega) > \alpha, \\ 0 & \text{if} \quad L_{H,t}(\omega) \leq \alpha, \end{cases} \tag{4.3}$$

where $\alpha, \phi > 0$ and $L_{H,t}(\omega) > 0$ is the labor input. Analogous technology applies to the production of $X^*_{H,t}(\omega)$, $X_{F,t}(\omega)$, and $X^*_{F,t}(\omega)$. For simplicity and consistent with the antecedents in the trade literature, labor is freely mobile across firms within the national borders and can be reallocated frictionlessly between production for local use and exports. However, there is no migration or outsourcing of labor across the national borders and, in the aggregate, labor is supplied inelastically.

4.3 Trade Shocks

Suppose shipping one unit of home variety to foreign costs an additional $\tau_t - 1 > 0$ units (i.e., *Samuelson's* "iceberg cost"). If the F.O.B. price of home variety (i.e., net of trade costs) charged to all individuals at home is given by $P_{H,t}(\omega) > 0$, then assuming home firms adopt the standard *Hotelling's* mill pricing strategy, the C.I.F. price of home exports to all foreign individuals is given by $P^*_{H,t}(\omega) = \tau_t P_{H,t}(\omega)$. In what follows, iceberg costs are exogenous to both firms and households. However, they consist not only of the standard time-invariant component, but also depend on the history and shocks, such that τ_t is generated by the following AR(1) process:

$$\textbf{TT:} \quad \tau_t = (1-\rho)\bar{\tau} + \rho\tau_{t-1} + \sigma\varepsilon_t, \tag{4.4}$$

where $\bar{\tau} > 1$, $-1 < \rho < 1$ and $\sigma > 0$. There are two ways to think about information and trade shocks in this model: (i) unanticipated (i.e., stochastic shocks that are drawn at random, such that $\varepsilon_t \sim \text{iid}(0,1)$); and (ii) anticipated (i.e., announced deterministic time paths of $\{\varepsilon_t\}_{t=0}^{\infty}$ known to all at all times, such that firms and individuals acquire perfect foresight). Moreover, trade shocks can be sequenced: (1) immediately (i.e., $\rho = 0$); or (2) gradually (i.e., $0 < \rho < 1$).

4.4 General Equilibrium

General equilibrium for countries $\{H, F\}$, individuals $\psi \in [0, \Psi + \Psi^*]$, varieties $\omega \in [0, \Omega + \Omega^*]$, and time periods $t = \{1, 2, ...\}$ is defined as a set of

1. **allocations:** $\{C_t(\psi), C^*_t(\psi), X_{H,t}(\psi,\omega), X^*_{H,t}(\psi,\omega), X_{F,t}(\psi,\omega), X^*_{F,t}(\psi,\omega), L_{H,t}(\psi,\omega),$ $L^*_{H,t}(\psi,\omega), L_{F,t}(\psi,\omega), L^*_{F,t}(\psi,\omega)\}_{t=1}^{\infty}$;
2. **prices:** $\{P_t, P^*_t, P_{H,t}(\omega), P^*_{H,t}(\omega), P_{F,t}(\omega), P^*_{F,t}(\omega), W^*_t\}_{t=1}^{\infty}$ with *numéraire* $W_t = 1 \,\forall\, t$;

conditional on

i. **exogenous shocks:** $\{\varepsilon_t, \varepsilon^*_t\}_{t=1}^{\infty}$;

ii. **constant parameters:** $\{\beta, \eta, \theta, \alpha, \alpha^*, \phi, \phi^*, \bar{\tau}, \bar{\tau}^*, \rho, \rho^*, \sigma, \sigma^*, L, L^*, \Psi, \Psi^*, \Omega, \Omega^*\}$;

iii. **pre-determined state:** $\{\tau_{t-1}, \tau^*_{t-1}, X_{H,t-1}(\omega), X^*_{H,t-1}(\omega), X_{F,t-1}(\omega), X^*_{F,t-1}(\omega)\}_{t=1}^{\infty}$;

that satisfy

a. **utility maximisation:** choosing $\{X_{H,t}(\psi,\omega), X_{F,t}(\psi,\omega)\}$ subject to the feasibility constraint $P_t C_t(\psi) = \int_0^{\Omega} P_{H,t}(\omega) X_{H,t}(\psi,\omega) d\omega + \int_0^{\Omega^*} P_{F,t}(\omega) X_{F,t}(\psi,\omega) d\omega$ to maximize (4.1) taking prices $\{P_{H,t}(\omega), P_{F,t}(\omega), P_t\}_{t=1}^{\infty}$ and mass $\{\Omega, \Omega^*\}$ as given (analogous for foreign);

b. **profit maximisation:** choosing $\{P_{H,t}(\omega), X_{H,t}(\omega)\}$ in order to maximize expected present discounted value of profits $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [P_{H,t}(\omega) X_{H,t}(\omega) - W_t L_{H,t}(\omega)]$ subject to (4.3) and taking as given the utility-maximising demand for variety ω as well as $\{W_t, \Omega, \Omega^*\}$, where $0 < \beta < 1$ is a constant and $\mathbb{E}_0$ is the rational expectations operator (analogous for foreign);

c. **market clearing & free entry conditions:** $\int_0^{\Omega} \int_0^{\Psi} [L_{H,t}(\psi,\omega) + L^*_{H,t}(\psi,\omega)] d\psi d\omega = L$, $P_{H,t}(\omega) X_{H,t}(\omega) = W_t L_{H,t}(\omega)$, $P^*_{H,t}(\omega) X^*_{H,t}(\omega) = W_t L^*_{H,t}(\omega)$, $\int_0^{\Psi} X_{H,t}(\psi,\omega) d\psi = X_{H,t}(\omega)$, $\int_0^{\Psi^*} X^*_{H,t}(\psi,\omega) d\psi = X^*_{H,t}(\omega)$ (analogous for foreign).

4.5 Backward-Looking Demand

Households choose how much of each variety to consume subject their feasibility constraint based on their deep habit preferences. It can easily be shown that unlike in the standard CES setup, the utility-maximising demand for each variety in our model is *recursive* and given by

$$X_{H,t}(\psi,\omega) = \left[\frac{P_{H,t}(\omega)}{P_t}\right]^{-\eta} C_t(\psi) X_{H,t-1}(\omega)^{\theta(\eta-1)}. \quad (4.5)$$

Observe that at time t each individual ψ chooses to consume more of H variety ω the more all individuals in H consumed ω at time $t-1$ (i.e., $X_{H,t}(\psi,\omega)$ is increasing in $X_{H,t-1}(\omega)$ assuming that $\eta > 1$ and $\theta > 0$). This dynamic feature is often referred to as "catching up with the Joneses good-by-good" and it induces delayed substitution in response to shocks. Without deep habits (i.e., $\theta \to 0$), demand for each variety by each individual is static. In general, demand exhibits standard properties, such as income effects (i.e., $X_{H,t}(\psi,\omega)$ is increasing in $C_t(\psi)$) and substitution effects (i.e., $X_{H,t}(\psi,\omega)$ is decreasing in the price of $P_{H,t}(\omega)$ relative to the aggregate cost of living P_t). Crucially, individual consumption decisions are too "small" to influence the population-wide consumption history, which makes consumer behaviour in equilibrium purely *backward*-looking.[13] We think that this is a realistic feature of the model, since it implies that trade is less price-elastic in the short-run than in the long-run consistent with the empirical evidence (Boehm et al. (2023)).

4.6 Forward-Looking Price Markups

Rational firms recognize the sluggish demand adjustment in response to shocks. And if firms are patient, forward-looking, and have market power, then choosing a price and output that only maximizes profits here and now is generally sub-optimal. Instead, they can exploit the expected future demand time path by recognizing that the population is addicted to consuming their variety. Specifically, if demand is expected to pick up in the future, firms can charge a relatively lower price today and over time build up addiction to their variety, thereby increasing profitability over the long term. Formally, firms price consumption habits in by setting a forward-looking price markup that maximizes the expected present discounted value of profits, which is given by

$$\underbrace{\frac{\phi P_{H,t}(\omega)}{W_t}}_{\substack{\text{forward-looking} \\ \text{(gross) markup}}} = \underbrace{\frac{\eta}{\eta-1}}_{\substack{\text{constant} \\ \text{(gross) markup}}} \times \underbrace{\frac{P_{H,t}(\omega)X_{H,t}(\omega)}{P_{H,t}(\omega)X_{H,t}(\omega) + \theta\beta\mathbb{E}_t[P_{H,t+1}(\omega)X_{H,t+1}(\omega)]}}_{\substack{\text{expected sales} \\ \text{growth component}}}, \quad (4.6)$$

where $0 < \beta < 1$ is the discount factor, $\mathbb{E}_t[\cdot]$ is the rational expectations operator with an information set up to and including date t, and $W_t/\phi > 0$ is the (gross) marginal cost of production (see Online Appendix A.1 and A.2 for more formal details). From this it can clearly be seen that markups fall when expected future sales $\mathbb{E}_t[P_{H,t+1}(\omega)X_{H,t+1}(\omega)]$ rise relative to current sales $P_{H,t}(\omega)X_{H,t}(\omega)$, which illustrates the fact that firms factor in the notion that "old habits die hard". Whether trade shocks are expected or hit firms as a complete surprise therefore makes a difference.

[13]Goods and services are assumed to be perishable and there is no trade in financial assets within or across the borders. Our framework therefore does not permit precautionary behaviour, such as panic buying, or forward-looking consumption smoothing. Incorporating either one of these features could be an interesting extension of our model.

4.7 Canonical Representation

To build intuition, we derive a simple canonical representation of the model under a select-few simplifying assumptions in the spirit of Krugman (1979, 1980).

Proposition 1. *Suppose H and F are fully symmetrical with: (i) identical technology and tastes* ($\alpha = \alpha^* > 0$, $\phi = \phi^* > 0$, *and* $\eta = \eta^* > 1$)*; (ii) equal size* ($L = L^* > 0$, $\Psi = \Psi^* > 0$, *and* $\Omega = \Omega^* > 0$)*; and (iii) equivalent iceberg costs* ($\tau_t = \tau_t^* > 1$)*. Define the import penetration ratio as* $S_{F,t} := 1 - \int_0^{\Psi}\int_0^{\Omega}(P_{H,t}(\omega)X_{H,t}(\psi,\omega))/(P_tC_t(\psi)) \equiv 1 - S_{H,t} \in [0,1]$*. Suppose further that in equilibrium all firms and individuals are symmetrical. Furthermore, let* $S_{H,t} = S^*_{F,t} := s_t$, $\phi P_{H,t} = \phi^* P^*_{F,t} W_t^{*-1} := \mu_t$, *and* $C_t = C_t^* := c_t$*. Without any loss of generality, assume that fixed production costs are given by* $\alpha = \gamma \bar{s} L \Omega^{-1} > 0$ *with* $0 < \gamma < 1$*. Then the aggregate general equilibrium conditions are characterized by the following system of stochastic difference equations:*

$$\textbf{PP:} \quad \mu_t = \left(\frac{\eta}{\eta - 1}\right)\frac{s_t}{s_t + \theta\beta\mathbb{E}_t\left[s_{t+1}\right]}, \tag{4.7}$$

$$\textbf{SS:} \quad s_t = (\mu_t c_t)^{1-\eta}\left(s_{t-1} - \gamma\bar{s}\right)^{\theta(\eta-1)}(L\phi)^{(1+\theta)(\eta-1)}, \tag{4.8}$$

$$\textbf{CC:} \quad \mu_t c_t = \phi^{1+\theta}\left[\left(s_{t-1} - \gamma\bar{s}\right)^{\theta(\eta-1)} + \tau_t^{1-\eta}\left(1 - s_{t-1} - \gamma\bar{s}\right)^{\theta(\eta-1)}\right]^{1/(\eta-1)}, \tag{4.9}$$

in conjunction with the exogenous law of motion for iceberg costs in (4.4)*, which altogether simultaneously determines* $\{\mu_t, s_t, c_t, \tau_t\}_{t=1}^{\infty}$ *assuming that the initial conditions* $\tau_0 = \bar{\tau} > 1$ *and* $s_0 = \bar{s} \in (0,1)$ *are fixed and known.*

Proof. See Online Appendix A.3.[14] □

The canonical representation is flexible and captures many desirable features of transitional dynamics, such as anticipation, sequencing, and delayed substitution parsimoniously. Independent of habits, the CC and TT relationships together imply that aggregate consumption c_t is decreasing in iceberg costs τ_t and crucially depends on shock sequencing ($-1 < \rho < 1$). The SS relationship shows that independent of shock sequencing, it takes time for households with habits $\theta > 0$ to substitute home and foreign varieties when shocks to iceberg costs erupt. The import penetration ratio $1 - s_t$ and consumption c_t are therefore more persistent than implied by shock sequencing. But observe that unlike consumption, the import penetration ratio is purely backward-looking and responds to trade shocks only when they actually hit the economy. By contrast, insofar as firms are sufficiently patient $0 < \beta < 1$ and varieties are addictive $\theta > 0$, PP shows that the aggregate markup is forward-looking and increasing in the expected future import penetration ratio $1 - \mathbb{E}_t[s_{t+1}]$, which is in turn decreasing in the expected future iceberg costs $\mathbb{E}_t[\tau_{t+1}]$. And because aggregate consumption c_t is inversely related to the aggregate markup μ_t, the aggregate welfare outcomes as measured by consumption depend not just on the realized trade shocks, but also on the anticipation of impending future trade shocks. However, if we switch habits off by setting $\theta = 0$, it can clearly be seen that markups are constant irrespective of the shock sequencing and we revert back to the standard CES welfare outcomes that no longer depend on expectations.

[14] It can further be shown that output is determined by the combination of the free entry condition and technology, namely $x_t = L\phi(s_t - \gamma\bar{s})$, where $X_{H,t} = X^*_{F,t} := x_t$, which is analogous to what Krugman (1979) refers to as the downward-sloping "ZZ" relationship.

To elaborate on that, note that our model nests many special cases of interest. First, without habits $\theta \to 0$ and without iceberg costs $\tau_t \to 1$, the model is static with fixed markups $\bar{\mu} = \eta/(\eta-1)$, fixed consumption $\bar{c} = 2^{1/(\eta-1)}\phi/\bar{\mu}$, and fixed import penetration ratio $1-\bar{s} = (2-L^{\eta-1})/2$. Second, it is easy to see that with shocks to iceberg costs $\tau_t > 1$, but without habits $\theta \to 0$, markups remain fixed $\bar{\mu} = \eta/(\eta-1)$ and the entirety of the transitional dynamics depends only on shock sequencing. Third, with iceberg costs $\tau_t > 1$ and with habits $\theta > 0$, but without patience $\beta \to 0$, markups are also fixed $\bar{\mu} = \eta/(\eta-1)$, but now the transitional dynamics depend both on habits and sequencing. Fourth, with habits $\theta > 0$, but no trade policy shocks $\tau_t = \bar{\tau}$, the model is stuck in the steady state in which markups are fixed, but lower than in the model without habits by a factor of $1/(1+\theta\beta)$.[15]

4.8 Parameter Calibration

Table 1 presents the values of the calibrated parameters in our model. We set $\beta = 0.95$ in line with the standard real business cycle literature. We normalize the level of productivity to unity, such that $\phi = 1$. The steady state value of the import penetration ratio (IPR) measured as $1 - \bar{s} = 0.07$ is taken from Arkolakis et al. (2012), such that the home bias parameter $\bar{s} = 0.93$. The price markup is set equal 20%, such that $\mu = 1.2$, which implies the standard value for the elasticity of substitution $\eta = 6$ absent of habits (i.e., when $\theta \to 0$). We set the steady state value of the iceberg costs $\bar{\tau}$ equal to 1.678, which corresponds closely to the average trade cost estimates in Anderson & van Wincoop (2004). The scale of fixed costs γ is set equal to 0.03, which satisfies the non-negativity constraint for foreign output in the steady state (i.e., $1 - (1+\gamma)\bar{s} > 0$). Following Ravn et al. (2006) and Havranek et al. (2017), we set the baseline value for the habit intensity θ equal to 0.1, such that $\eta = \bar{\mu}(1+\theta\beta)/(\bar{\mu}(1+\theta\beta) - 1) \simeq 4.18$ keeping $\bar{\mu} = 1.2$ fixed. As a robustness check, we also consider higher and lower values of θ (i.e., $\theta = 0$ and $\theta = 0.2$). To study how much trade persistence habits generate, we initially set $\rho = 0$, such that the law of motion for the iceberg costs simplifies to a MA(1) process (i.e., $\tau_t = \bar{\tau} + \varepsilon_t$). We also explore the role of the more empirically relevant gradual trade cost adjustments, where we set $\rho = 0.7$. Finally, we set $\sigma = 0.01 \times (1-\rho)$, which allows us to generate a one percentage point rise in the iceberg costs when shocks are either immediate (i.e., $\rho = 0$) or when they are phased in gradually (i.e., $\rho = 0.7$).

Table 1: Baseline Calibration of Parameters

Parameter	Value	Description
β	0.95	Time Preference
ϕ	1	Productivity
$\bar{\mu}$	1.2	Gross Price Markup
γ	0.03	Scale of Fixed Entry Costs
$1-\bar{s}$	0.07	Import Penetration Ratio (IPR)
$\bar{\tau}$	1.678	Iceberg Costs
ρ	$[0, 0.7]$	Shock Persistence
σ	0.01	Size of Shocks
θ	$[0, 0.1, 0.2]$	Habit Intensity

[15]For this reason, we calibrate the steady state markup $\bar{\mu}$ to a standard value in the literature. Provided we choose the habit intensity parameter θ freely, our elasticity of demand is restricted to $\eta = \bar{\mu}(1+\theta\beta)/(\bar{\mu}(1+\theta\beta) - 1) > 1$.

4.9 Unanticipated Trade Protectionism Shock

Figure 2 presents the model-implied transitional dynamics following an unanticipated one percentage point increase in the iceberg costs $\tau_t > 1$. To distinguish the role of sequencing from delayed substitution, we consider alternative parameterisations of the model, namely: (i) with immediate and gradual rise in iceberg costs $0 \leq \rho < 1$ (see subplots (1) and (2) of Figure 2); and (ii) with and without habits $\theta \geq 0$ (see different coloured lines in Figure 2).

4.9.1 Unanticipated Shock without Habits: $\theta = 0$

When habits are switched off, the transitional dynamics are driven solely by the sequencing of the shock. There are no transitional dynamics when shocks are immediate $\rho = 0$. Instead, there is a one-off rise in the iceberg costs at $h = 0$ followed by a fall in the import penetration ratio of around 0.2% and a fall in consumption of around 0.04%. With gradual shocks $\rho = 0.7$, there are transitional dynamics insofar as it takes 10-15 periods for iceberg costs to rise by one percentage point. Although adjustment now it takes time, both the import penetration ratio and consumption eventually fall by the same magnitude as before. However, without habits, markups are constant irrespective of shock sequencing, which is inconsistent with the evidence in Section 3.

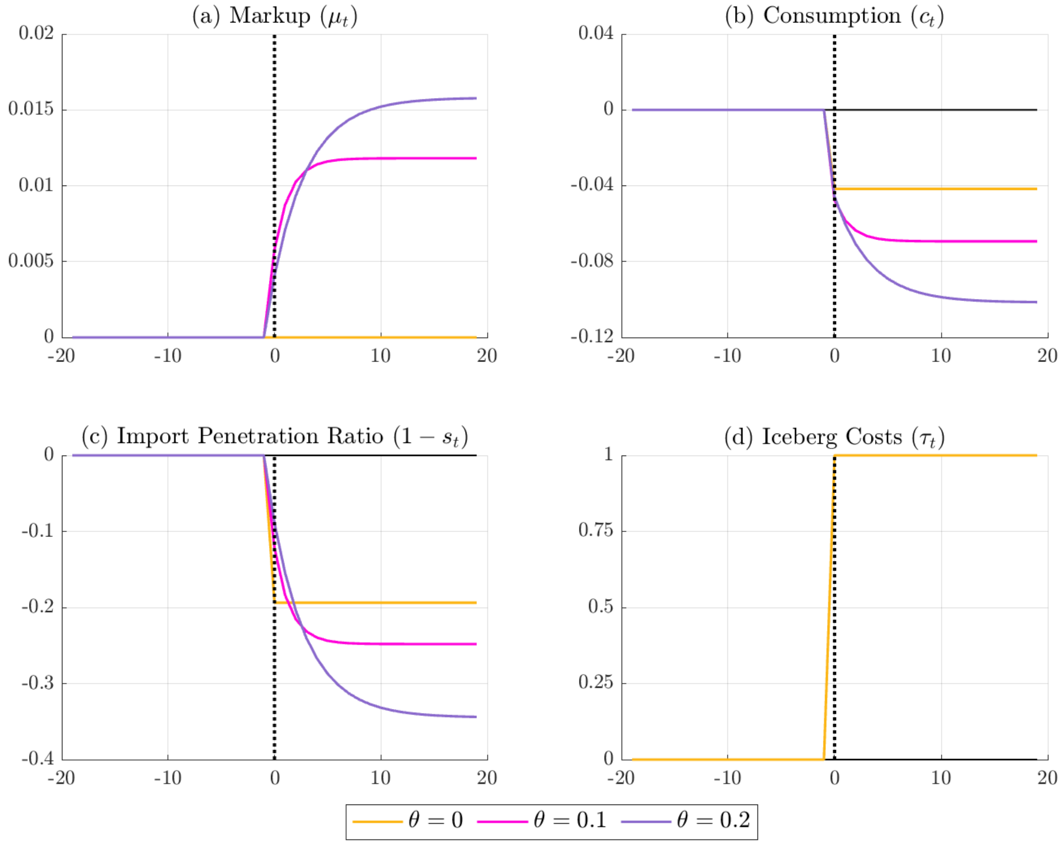
4.9.2 Unanticipated Shock with Habits: $\theta > 0$

With habits, there are transitional dynamics irrespective of the shock sequencing and markups are no longer constant. With immediate shocks, greater habit intensity (i.e., higher value of $\theta > 0$) induces two notable differences in impulse responses compared to the static model. First, there is delayed substitution. Second, the initial impulse responses ($h = 0$) are subdued and simultaneously the eventual responses ($h = 20$) are amplified. Specifically, with $\theta = 0.2$, consumption eventually falls by more than 0.1%, which is more than twice as large compared to when habits are switched off, the import penetration ratio eventually falls by around 0.35% compared to the previous 0.2%, and the markup now rises by up to 0.015%. Qualitatively, these model-implied cumulative impulse responses closely match the non-cumulative ones established empirically in Section 3.

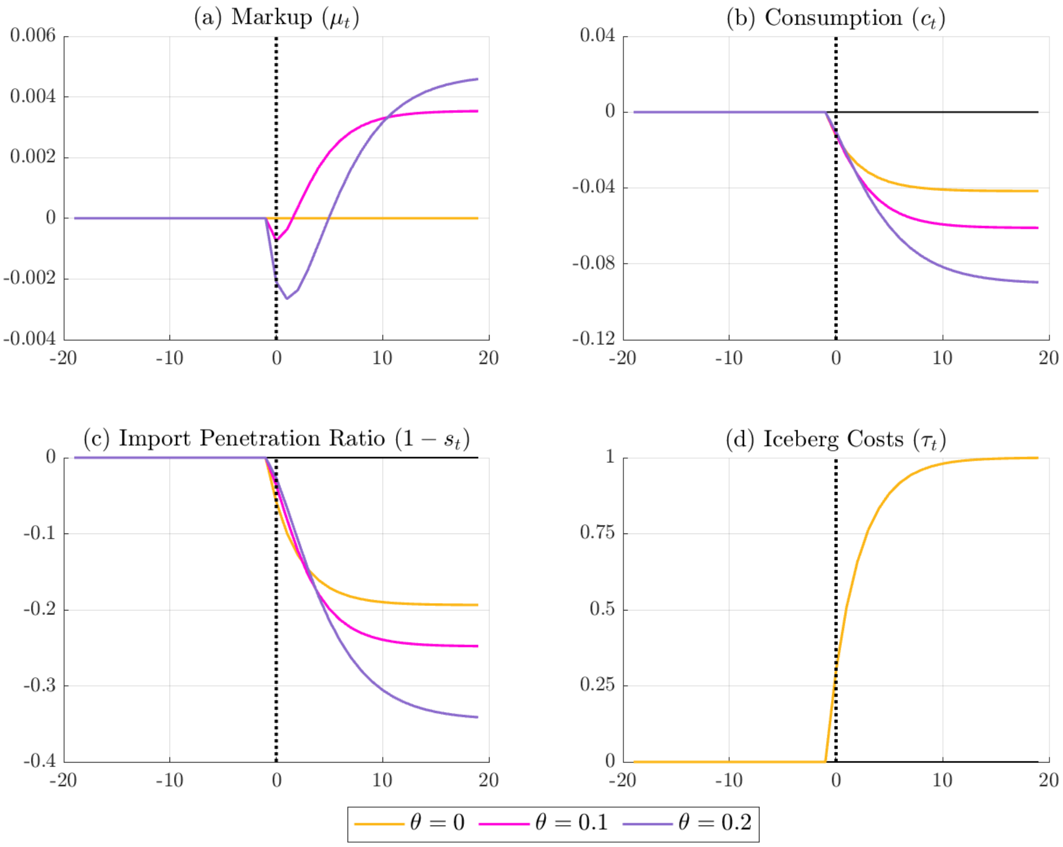
Intuitively, addicted consumers do not substitute foreign for home varieties right away as captured by the population-wide consumption history (i.e., "old habits die hard"). This explains the subdued initial response of the import penetration ratio and consumption. But as time passes after the shock, the entire population shifts away from foreign to home varieties at a geometrically decaying rate controlled by the habit intensity $\theta > 0$ and the elasticity of substitution $\eta > 1$. Every individual observes, mimics, and in doing so exacerbates the population-wide substitution since all individuals are "catching up with the Joneses". This explains the amplified eventual response of the import penetration ratio and consumption. Markups increase upon impact, because after the shock occurs, firms expect future domestic sales to rise, but by less than they rise today, owing to the geometrically decaying rise in demand over time. The gradual rise in markups persists over time until "catching up with the Joneses" eventually stops, at which point expected future sales and actual sales realign. With greater habit intensity, the difference between the current sales and expected future sales is initially smaller, but at the same time that difference prevails for longer. This explains why it takes time for markups to fully unfold after the shock hits the economy.

Figure 2: Cumulative Response to Unanticipated 1% Rise in Iceberg Costs ($\Delta\tau_0 = 0.01 \times (1 - \rho)$)

(1) Immediate ($\rho = 0$)



(2) Gradual ($\rho = 0.7$)



The vertical axis measures *cumulative* Impulse Response Functions (IRFs) as percentage point deviations from the initial steady state. The horizontal axis indicates discrete time periods. There are three different cases: (i) no habits (i.e., yellow line when $\theta = 0$); (ii) baseline habits (i.e., pink line when $\theta = 0.1$); and (iii) intense habits (i.e., purple line when $\theta = 0.2$). When shocks to the iceberg costs are unanticipated, we calculate IRFs by solving for the first-order perturbation to the policy function (Schmitt-Grohé & Uribe (2004)) (see online appendix B for a formal description).

With gradual shocks and habits, the eventual responses are qualitatively similar, but the transitional dynamics in the immediate aftermath of the shock are different. First, iceberg costs rise at a geometrically decaying rate controlled by parameter $0 < \rho < 1$. Second, the import penetration ratio adopts an "S-shaped" type response, such that at first it falls at a geometrically increasing rate before reverting to a geometrically decreasing rate as before. However, eventually the import penetration ratio falls by around the same magnitude irrespective of the shock sequencing, since it is backward-looking and does not depend on expectations. Third, because of this S-shaped response, markups initially fall before they start to rise. With greater habit intensity comes both a more pronounced initial dip and eventual surge in markups. However, for a given habit intensity, markups eventually rise by less the more gradual is the sequencing of the shock. Fourth, because markups fall upon impact and eventually rise by less, consumption ultimately falls by less, which underscores the fact that transitional dynamics of markups influence aggregate welfare outcomes.

When habits are interacted with shock sequencing, the key insight is that "catching up with the Joneses" takes longer to start because the initial change in the iceberg costs is smaller, such that even less substitution occurs upon impact. Firms at first expect future sales to rise by more than the current sales because the full extent of the change in the iceberg costs is not yet phased in. This explains why markups initially fall. But as time passes and expected future changes in the iceberg costs subside, "catching up with the Joneses" intensifies. At a certain point, future expectations flip, such that firms start to expect future sales to rise by less than the current sales, just as they do when shocks are immediate. But by then, a non-negligible extent of the import substitution has already occurred and demand for imports is now already more elastic. This explains why markups eventually rise even if shocks are gradual, but ultimately by less than when shocks are immediate.

4.10 Anticipated Trade Protectionism Shock

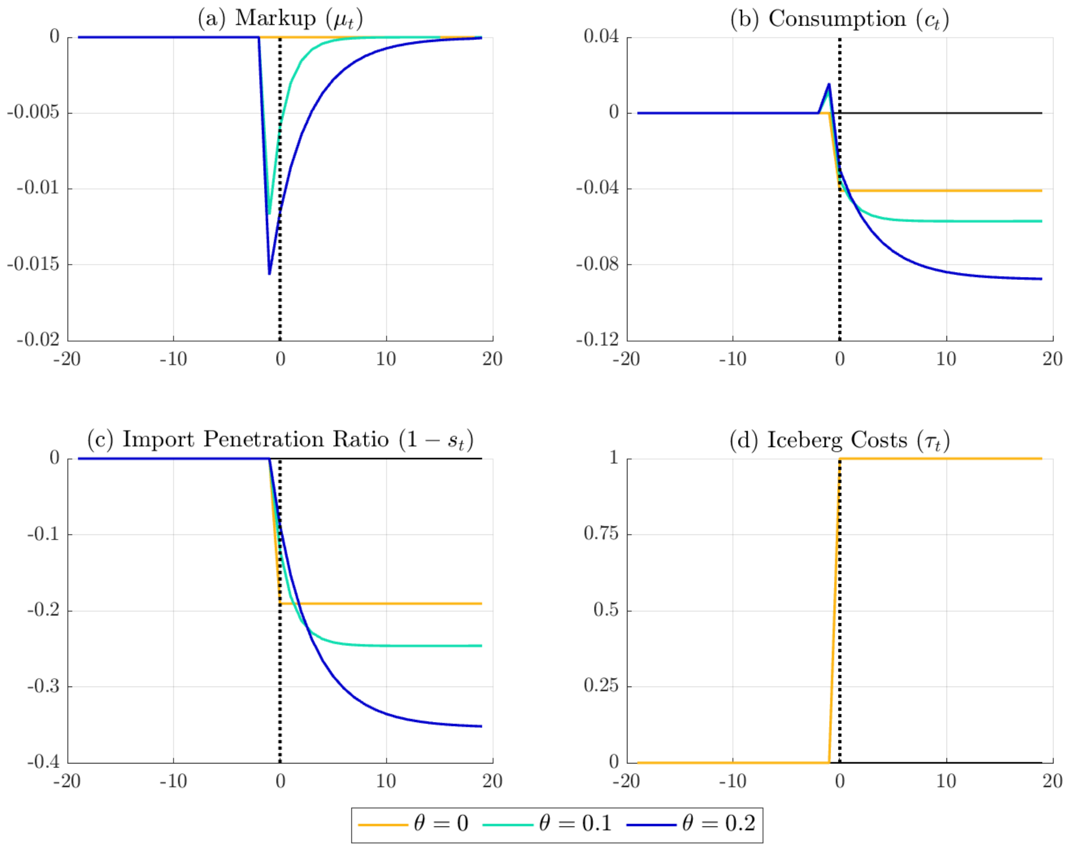
Figure 3 presents the model-implied transitional dynamics following an identical increase in iceberg costs at $h = 0$, only now the shock is (credibly) announced in advance at $h = -20$. To see what difference, if any, comes with anticipation, we consider the same parameterisations of the model, namely: (i) with immediate and gradual rise in iceberg costs $0 \leq \rho < 1$ (see subplots (1) and (2) of Figure 3); and (ii) with and without habits $\theta \geq 0$ (see different coloured lines in Figure 3).

As explained above, the model without habits is purely backward-looking in which markups are constant and future expectations have no influence on the transitional dynamics. Setting $\theta = 0$ therefore delivers identical responses irrespective of whether the shock is anticipated or unanticipated (compare yellow lines in Figures 2 and 3). This is a special case in which anticipation is irrelevant, but it goes against the empirical stylized facts that we establish in Section 3. What we show next is that a model with habits generates qualitatively different responses to anticipated and unanticipated shocks that are in many ways consistent those in Section 3.

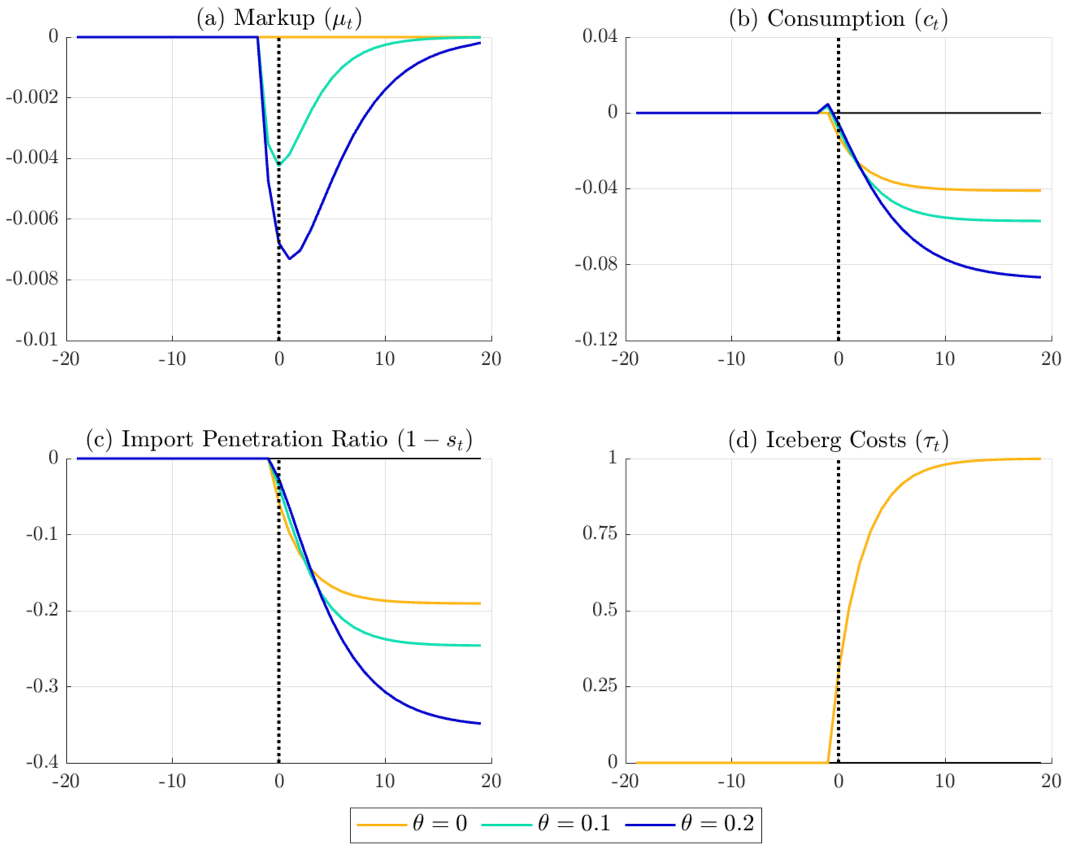
Consider the case of anticipated and immediate trade protectionism shock $\rho = 0$ with habits $\theta > 0$. First, notice that the import penetration ratio response is virtually the same as before in all parameterisations of the model because the import penetration ratio is backward-looking and independent of expectations (see subplots (c) in Figures 2 and 3). Second, exactly one period before the shock hits the economy, markups fall and consumption rises, which is starkly different from the case of unanticipated shocks (see subplots (a) and (d) in Figures 2 and 3). But after the

Figure 3: Cumulative Response to Anticipated 1% Rise in Iceberg Costs ($\Delta\tau_0 = 0.01 \times (1-\rho)$)

(1) Immediate ($\rho = 0$)



(2) Gradual ($\rho = 0.7$)



The vertical axis measures *cumulative* time paths as percentage point deviations from the initial steady state. The horizontal axis indicates discrete time periods. There are three different cases: (i) no habits (i.e., yellow line when $\theta = 0$); (ii) baseline habits (i.e., pink line when $\theta = 0.1$); and (iii) intense habits (i.e., purple line when $\theta = 0.2$). When shocks are anticipated, we calculate the time paths of the system conditional on the time path of the shocks following Laffargue (1990), Boucekkine (1995), and Juillard (1996) (see Online Appendix C for a formal description).

shock actually hits the economy, markups start to gradually rise and consumption gradually falls similar to the unanticipated shock setting. The key difference is that when the shock is anticipated, markups fall so much so in the run-up to the shock that even when the shock hits the economy and markups start to gradually rise, the cumulative response never ends up actually rising above zero. Welfare outcomes in response to anticipated shocks are therefore different than in the case of unanticipated shocks because: (i) initially it gets better before eventually it gets worse; and (ii) consumption eventually falls by less because in the long-run markups remain unchanged. The outcomes are very similar when anticipated shocks are phased in gradually $0 < \rho < 1$ and there are habits $\theta > 0$, except markups initially fall by less and it takes longer for them to bounce back.

The basic idea is that when firms anticipate future iceberg costs to rise, they cut their markups before the shock even hits the economy so as to build an addicted consumer base. If they discount the short-run profits prior to the realisation of the shock sufficiently, then this pre-emptive fall in markups allows firms to keep domestic demand and sales elevated for longer even after the shock hits the economy, thereby increasing the present discounted value of expected future profits.[16] The fact the cumulative markup response to anticipated trade barriers is positive in practice, but not in our theory, can in part be reconciled by the fact that not all firms in practice are fully-informed and rational, which is what our theory explicitly assumes. If we divided the continuum of firms into those that are rational and those that incorporate news with a lag, the aggregate theoretical markup response would then emulate the empirical response more closely by exhibiting an eventual rise.

4.11 Welfare Loss

To succinctly summarize the welfare outcomes between different hypothetical settings of the model, we compile Table 2, which quantifies the welfare loss of an exogenous 10% increase in iceberg costs in terms of percentage changes in real units of aggregate consumption. Given that our environment is dynamic when $0 < \rho < 1$ and/or $\theta > 0$, the ubiquitous welfare loss formula based on the long-run import penetration ratio and long-run trade elasticity put forth by Arkolakis et al. (2012) is no longer a sufficient statistic because it does not take into the account the effects of transitional dynamics.[17] In general, a closed-form solution to the welfare loss formula in a dynamic environment does not exist as pointed out by Alessandria et al. (2021). Therefore, in the spirit of Alessandria et al. (2021), we calculate the welfare loss of trade protectionist shocks at each time horizon $h = \{0, 1, 2, ...\}$ directly from the impulse responses in Figures 2 and 3 that fully characterize the general equilibrium responses of aggregate consumption.

The welfare losses in Table 2 are calculated along the following four dimensions: (i) anticipated or unanticipated nature of the shock; (ii) immediate or gradual sequencing of the shock $0 \leq$

[16] The reason why firms wait until just one time period before the shock is realized to cut markups even if the announcement is made many time periods in advance is because consumers have a "short memory" in that preferences take into the account just one lag of the population consumption history. It is straightforward to extend our model and consider more lags in demand similar to Ravn et al. (2006), which leads to more leads in markups, such that anticipation of the shock would then produce even richer transitional dynamics in the run-up to the shock.

[17] In general, welfare outcomes depend on the transitional dynamics both because the trade elasticity may be dynamic and because the aggregate consumption response exhibits lags independent of the trade elasticity due to other forces of persistence in the model. For completeness, Online Appendix D provides our estimates of the dynamic trade elasticity under various parameterisations of the model. However, given that trade flows in our model are dynamic, but purely backward-looking, the dynamic trade elasticity in equilibrium does not depend on anticipation. For this reason, we divert our focus to the transitional dynamics of the economy as a whole, which can depend on expectations.

Table 2: Welfare Loss from an Exogenous 10% Increase in Iceberg Costs ($\Delta\tau_0 = 0.1 \times (1 - \rho)$)

	(i) Without Habits	(ii) With Habits			
		(1) Variable Markups		(2) Fixed Markups	
Trade Protection Shocks	$\theta = 0$	$\theta = 0.1$	$\theta = 0.2$	$\theta = 0.1$	$\theta = 0.2$
(a) Unanticipated and Immediate ($\rho = 0$)					
Short-Run ($h = 0$)	-0.70%	-0.79%	-0.77%	-0.70%	-0.70%
Long-Run ($h = 20$)	-0.70%	-1.17%	-1.70%	-0.96%	-1.43%
(b) Unanticipated and Gradual ($\rho = 0.7$)					
Short-Run ($h = 0$)	-0.21%	-0.20%	-0.18%	-0.21%	-0.21%
Long-Run ($h = 20$)	-0.70%	-1.02%	-1.50%	-0.96%	-1.43%
(c) Anticipated and Immediate ($\rho = 0$)					
Short-Run ($h = 0$)	-0.70%	-0.59%	-0.50%	-0.70%	-0.70%
Long-Run ($h = 20$)	-0.70%	-0.95%	-1.50%	-0.96%	-1.43%
(d) Anticipated and Gradual ($\rho = 0.7$)					
Short-Run ($h = 0$)	-0.21%	-0.14%	-0.10%	-0.21%	-0.21%
Long-Run ($h = 20$)	-0.70%	-0.95%	-1.48%	-0.96%	-1.43%

$\rho < 1$; (iii) habit intensity $\theta \geq 0$; and (iv) short-run ($h = 0$) versus long-run ($h = 20$) time horizon. In addition, we consider a fixed markup setting with habits $\theta > 0$, where we effectively set $\beta = 0$. Altogether, this allows us to decompose the aggregate welfare loss into: (a) the traditional static component that can be calculated using the Arkolakis et al. (2012) formula; (b) the impact of sequencing and delayed substitution in the absence of price distortions, in which case expectations are irrelevant; and (c) the composite effects of expectations that act through dynamic price distortions and potentially interact with the sequencing of the shock.

We first find that without habits $\theta = 0$, the welfare loss of immediate trade protectionism $\rho = 0$ is equal to 0.7% independent of the time horizon. Unsurprisingly, this estimate corresponds exactly to the magnitude predicted by the Arkolakis et al. (2012) formula, since the static counterpart of our model features a static trade elasticity of $1 - \eta = -5$ and an import penetration ratio of $1 - \bar{s} = 0.93$, which is an identical calibration theirs. With gradual sequencing $0 \leq \rho < 1$ of the same 10% increase in the iceberg costs and independent of anticipation, the short-run welfare loss falls to 0.21%. However, in the long-run, the welfare loss reaches the same magnitude of 0.7% as when shocks are immediate. Shock sequencing in and of itself therefore only delays the inevitable: gradualism attenuates the short-run welfare loss, but has no effect on the long-run welfare loss when compared to the traditional static welfare loss estimates.

With habits $\theta > 0$ and fixed markups $\beta = 0$, the welfare loss remains independent of expectations. The magnitude of the short-run welfare loss remains the same as the model without habits and the eventual response depends primarily on the sequencing of the shock. However, in the long-run, the welfare loss increases from 0.7% to 0.96-1.43% depending on the habit intensity. Delayed import substitution implied by the "catching up with the Joneses" mechanism therefore amplifies the long-run welfare loss of trade protectionism. And increasingly so the greater is the habit intensity $\theta > 0$ and the closer is the value of the elasticity $\eta > 1$ to unity.

With habits $\theta > 0$ and variable markups $0 < \beta < 1$, the welfare loss upon impact rises from 0.7% to around 0.77-0.79% and eventually reaches 1.17-1.70% if the shock is unanticipated and immediate $\rho = 0$, which is the worst welfare outcome of all in our model. Recall that this is when markups rise above the initial level as soon as the shock hits the economy and they continue to rise monotonically at a geometrically decaying rate (see subplot (1) in Figure 2). Moving from immediate to gradual unanticipated shocks $0 \leq \rho < 1$ lowers not only the short-run welfare loss to 0.18-0.2%, but also the long-run welfare loss to 1.02-1.5% because markups upon impact actually fall and eventually rise by less (see subplot (2) in Figure 2).

With anticipated and immediate shocks $\rho = 0$, the welfare loss upon impact is the lowest of all immediate shock scenarios and equals 0.5-0.59%, but in the long-run rises to 0.95-1.5%, which is very similar to the outcome when shocks are unanticipated and gradual. This can be explained by the fact that markups fall before the shock actually hits the economy, such that even though markups rise upon impact, they start rising from below the initial steady state. But in the long-run, when shocks are anticipated, markups return to the initial steady state, whereas when gradual shocks are unanticipated, markups eventually rise, but by much less compared to when unanticipated shocks are immediate. Finally, when the shocks are anticipated and gradual $0 \leq \rho < 1$, the short-run welfare loss is 0.1-0.14%, which is the lowest of all settings including the traditional static model, but in the long-run it rises to 0.95-1.48%, which is greater than the traditional static model, but similar to all other settings except for unanticipated and immediate trade protection shocks. The basic idea is that anticipated shocks that are phased in gradually stabilize markup adjustment before and after the shock, which brings the welfare outcomes closer – albeit not entirely all the way – to the fixed markup setting that features delayed substitution.

5 Concluding Remarks

According to the conventional wisdom, trade protectionism abstracts the economy from foreign competition and increases domestic firm price markups. But the transitional dynamics of markups are not yet well-documented and not much is still known about whether markups increase monotonically or how long it takes for them to increase in practice. It also remains an open question whether trade and markup adjustment depend on the timing and expectations of trade policy announcement and enforcement. Our paper offers a first theoretical and empirical attempt to study the intricate relationship between trade barriers, markups, and expectations.

We are yet to learn more about how firms form expectations and in what ways they learn about the influence that trade policy exerts on their profitability over time. If we had access to high-frequency firm-level data on markups, the natural next step in our analysis would be to study how different firm-level characteristics influence expectation formation and learning. That line of work and our theoretical trade model with habits could then be easily merged with the existing influential works of Eaton & Kortum (2002), Melitz (2003), Bernard et al. (2003), and Atkeson & Burstein (2008) among others that consider the link between firm-level heterogeneity of productivity and markups, but not yet the potential existence of a link between firm-level heterogeneity of expectations and markups. However, even at the aggregate level, we find that markups respond significantly, but gradually, to trade shocks and that information about trade policy relayed through news in certain media outlets may influence not just the initial impact, but also the long-run adjustment of markups and welfare.

References

Abel, A. (1990), 'Asset Prices under Habit Formation and Catching Up with the Joneses', *American Economic Review* **80**(2), 38–42.

Alessandria, G. A., Khan, S. Y. & Khederlarian, A. (2019), Taking Stock of Trade Policy Uncertainty: Evidence from China's Pre-WTO Accession, Technical report, National Bureau of Economic Research.

Alessandria, G. & Choi, H. (2007), 'Do Sunk Costs of Exporting Matter for Net Export Dynamics?', *The Quarterly Journal of Economics* **122**(1), 289–336.

Alessandria, G., Choi, H. & Ruhl, K. J. (2021), 'Trade Adjustment Dynamics and the Welfare Gains from Trade', *Journal of International Economics* **131**, 103458.

Alvarez-Cuadrado, F., Casado, J. M. & Labeaga, J. M. (2016), 'Envy and Habits: Panel Data Estimates of Interdependent Preferences', *Oxford Bulletin of Economics and Statistics* **78**(4), 443–469.

Amiti, M., Itskhoki, O. & Konings, J. (2019), 'International Shocks, Variable Markups, and Domestic Prices', *Review of Economic Studies* **86**(6), 2356–2402.

Anderson, J. E. & van Wincoop, E. (2004), 'Trade Costs', *Journal of Economic Literature* **42**(3), 691–751.

Arias, J. E., Caldara, D. & Rubio-Ramírez, J. F. (2019), 'The Systematic Component of Monetary Policy in SVARs: An Agnostic Identification Procedure', *Journal of Monetary Economics* **101**, 1–13.

Arias, J. E., Rubio-Ramírez, J. F. & Waggoner, D. F. (2018), 'Inference Based on Structural Vector Autoregressions Identified With Sign and Zero Restrictions: Theory and Applications', *Econometrica* **86**(2), 685–720.

Arkolakis, C., Costinot, A., Donaldson, D. & Rodríguez-Clare, A. (2018), 'The Elusive Pro-Competitive Effects of Trade', *The Review of Economic Studies* **86**(1), 46–80.

Arkolakis, C., Costinot, A. & Rodríguez-Clare, A. (2012), 'New Trade Models, Same Old Gains?', *American Economic Review* **102**(1), 94–130.

Atkeson, A. & Burstein, A. (2008), 'Pricing-to-Market, Trade Costs, and International Relative Prices', *American Economic Review* **98**(5), 1998–2031.

Autor, D., Dorn, D., Katz, L. F., Patterson, C. & Van Reenen, J. (2020), 'The Fall of the Labor Share and the Rise of Superstar Firms', *The Quarterly Journal of Economics* **135**(2), 645–709.

Baldwin, R. E. (1992), 'Measurable Dynamic Gains from Trade', *Journal of Political Economy* **100**(1), 162–174.

Bernanke, B. S. & Blinder, A. S. (1992), 'The Federal Funds Rate and the Channels of Monetary Transmission', *American Economic Review* **82**(4), 901–921.

Bernard, A. B., Eaton, J., Jensen, J. B. & Kortum, S. (2003), 'Plants and Productivity in International Trade', *American Economic Review* **93**(4), 1268–1290.

Bilbiie, F. O., Ghironi, F. & Melitz, M. J. (2019), 'Monopoly Power and Endogenous Product Variety: Distortions and Remedies', *American Economic Journal: Macroeconomics* **11**(4), 140–74.

Binning, A. (2013), Underidentified SVAR models: A Framework for Combining Short and Long-run Restrictions with Sign-Restrictions, Working Paper 2013/14, Norges Bank.

Blanchard, O. J. & Kahn, C. M. (1980), 'The Solution of Linear Difference Models Under Rational Expectations', *Econometrica* **48**(5), 1305–1311.

Blanchard, O. J. & Quah, D. (1989), 'The Dynamic Effects of Aggregate Demand and Supply Disturbances', *American Economic Review* **79**(4), 655–673.

Blanchard, O. & Perotti, R. (2002), 'An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output', *The Quarterly Journal of Economics* **117**(4), 1329–1368.

Boehm, C. E., Levchenko, A. A. & Pandalai-Nayar, N. (2023), 'The Long and Short (Run) of Trade Elasticities', *American Economic Review* **113**(4), 861–905.

Boucekkine, R. (1995), 'An Alternative Methodology for Solving Nonlinear Forward-Looking Models', *Journal of Economic Dynamics and Control* **19**(4), 711–734.

Bown, C. P. (2021), 'The US–China Trade War and Phase One Agreement', *Journal of Policy Modelling* **43**(4), 805–843.

Burstein, A., Carvalho, V. M. & Grassi, B. (2020), Bottom-up Markup Fluctuations, NBER Working Papers 27958, National Bureau of Economic Research, Inc.

Caldara, D., Iacoviello, M., Molligo, P., Prestipino, A. & Raffo, A. (2020), 'The Economic Effects of Trade Policy Uncertainty', *Journal of Monetary Economics* **109**(C), 38–59.

Campbell, J. & Deaton, A. (1989), 'Why is Consumption So Smooth?', *The Review of Economic Studies* **56**(3), 357–373.

Campbell, J. Y. & Cochrane, J. H. (1999), 'By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior', *Journal of Political Economy* **107**(2), 205–251.

Canova, F. & de Nicolo, G. (2003), 'On the Sources of Business Cycles in the G-7', *Journal of International Economics* **59**(1), 77–100.

Canova, F. & Ferroni, F. (2021), A Hitchhiker's Guide to Empirical Macro Models, Working Paper Series WP-2021-15, Federal Reserve Bank of Chicago.

Carrasco, R., Labeaga, J. M. & López-Salido, J. D. (2005), 'Consumption and Habits: Evidence from Panel Data', *The Economic Journal* **115**(500), 144–165.

Chaloupka, F. (1991), 'Rational Addictive Behavior and Cigarette Smoking', *Journal of Political Economy* **99**(4), 722–742.

Chen, N., Imbs, J. & Scott, A. (2009), 'The Dynamics of Trade and Competition', *Journal of International Economics* **77**(1), 50–62.

Chintagunta, P., Kyriazidou, E. & Perktold, J. (2001), 'Panel Data Analysis of Household Brand Choices', *Journal of Econometrics* **103**(1), 111–153.

Chisik, R. (2003), 'Gradualism in Free Trade Agreements: A Theoretical Justification', *Journal of International Economics* **59**(2), 367–397.

Crowley, M. A., Exton, O. & Han, L. (2020), 'The Looming Threat of Tariff Hikes: Entry into Exporting under Trade Agreement Renegotiation', *AEA Papers and Proceedings* **110**, 547–51.

Crowley, M., Meng, N. & Song, H. (2018), 'Tariff Scares: Trade Policy Uncertainty and Foreign Market Entry by Chinese Firms', *Journal of International Economics* **114**, 96–115.

De Loecker, J., Eeckhout, J. & Unger, G. (2020), 'The Rise of Market Power and the Macroeconomic Implications', *The Quarterly Journal of Economics* **135**(2), 561–644.

De Loecker, J., Goldberg, P. K., Khandelwal, A. K. & Pavcnik, N. (2016), 'Prices, markups, and trade reform', *Econometrica* **84**(2), 445–510.

De Loecker, J. & Warzynski, F. (2012), 'Markups and Firm-Level Export Status', *American Economic Review* **102**(6), 2437–71.

Dixit, A. K. & Stiglitz, J. E. (1977), 'Monopolistic Competition and Optimum Product Diversity', *American Economic Review* **67**(3), 297–308.

Douch, M. & Edwards, T. H. (2021), 'The Bilateral Trade Effects of Announcement Shocks: Brexit as a Natural Field Experiment', *Journal of Applied Econometrics* .

Eaton, J. & Kortum, S. (2002), 'Technology, Geography, and Trade', *Econometrica* **70**(5), 1741–1779.

Feenstra, R. C., Luck, P., Obstfeld, M. & Russ, K. N. (2018), 'In Search of the Armington Elasticity', *The Review of Economics and Statistics* **100**(1), 135–150.

Fernández-Villaverde, J., Rubio-Ramírez, J. F., Sargent, T. J. & Watson, M. W. (2007), 'ABCs (and Ds) of Understanding VARs', *The American Economic Review* **97**(3), 1021–1026.

Gallaway, M. P., McDaniel, C. A. & Rivera, S. A. (2003), 'Short-Run and Long-Run Industry-Level Estimates of U.S. Armington Elasticities', *The North American Journal of Economics and Finance* **14**(1), 49–68.

Granziera, E., Moon, H. R. & Schorfheide, F. (2018), 'Inference for VARs Identified With Sign Restrictions', *Quantitative Economics* **9**(3), 1087–1121.

Hamilton, J. D. (2018), 'Why You Should Never Use the Hodrick-Prescott Filter', *The Review of Economics and Statistics* **100**(5), 831–843.

Handley, K. & Limão, N. (2017), 'Policy Uncertainty, Trade, and Welfare: Theory and Evidence for China and the United States', *American Economic Review* **107**(9), 2731–83.

Havranek, T., Rusnak, M. & Sokolova, A. (2017), 'Habit Formation in Consumption: A Meta-Analysis', *European Economic Review* **95**, 142–167.

Helpman, E. & Niswonger, B. (2022), 'Dynamics of Markups, Concentration, and Product Span', *American Economic Journal: Macroeconomics* **14**(3), 42–81.

Hodrick, R. J. & Prescott, E. C. (1997), 'Postwar U.S. Business Cycles: An Empirical Investigation', *Journal of Money, Credit and Banking* **29**(1), 1–16.

Imbs, J. & Mejean, I. (2015), 'Elasticity Optimism', *American Economic Journal: Macroeconomics* **7**(3), 43–83.

Jaimovich, N. & Floetotto, M. (2008), 'Firm Dynamics, Markup Variations, and the Business Cycle', *Journal of Monetary Economics* **55**(7), 1238–1252.

Juillard, M. (1996), Dynare: A Program for the Resolution and Simulation of Dynamic Models with Forward Variables Through the Use of a Relaxation Algorithm, CEPREMAP Working Papers (Couverture Orange) 9602, CEPREMAP.

Khan, S. Y. & Khederlarian, A. (2021), 'How Does Trade Respond to Anticipated Tariff Changes? Evidence from NAFTA', *Journal of International Economics* **133**, 103538.

Klein, P. (2000), 'Using the Generalized Schur Form to Solve a Multivariate Linear Rational Expectations Model', *Journal of Economic Dynamics and Control* **24**(10), 1405 – 1423.

Krugman, P. (1980), 'Scale Economies, Product Differentiation, and the Pattern of Trade', *American Economic Review* **70**(5), 950–959.

Krugman, P. R. (1979), 'Increasing Returns, Monopolistic Competition, and International Trade', *Journal of International Economics* **9**(4), 469 – 479.

Laffargue, J.-P. (1990), 'Résolution d'Un Modèle Macroéconomique Avec Anticipations Rationnelles', *Annales d'Économie et de Statistique* **17**, 97–119.

Levinsohn, J. (1993), 'Testing the Imports-as-Market-Discipline Hypothesis', *Journal of International Economics* **35**(1), 1–22.

Melitz, M. J. (2003), 'The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity', *Econometrica* **71**(6), 1695–1725.

Melitz, M. J. & Ottaviano, G. I. P. (2008), 'Market Size, Trade, and Productivity', *Review of Economic Studies* **75**(1), 295–316.

Mertens, K. & Ravn, M. O. (2014), 'A Reconciliation of SVAR and Narrative Estimates of Tax Multipliers', *Journal of Monetary Economics* **68**(S), 1–19.

Metiu, N. (2021), 'Anticipation Effects of Protectionist U.S. Trade Policies', *Journal of International Economics* **133**, 103536.

Meyer-Gohde, A. (2010), 'Matlab Code for One-Sided HP-Filters', QM&RBC Codes, Quantitative Macroeconomics & Real Business Cycles.

Miranda-Agrippino, S. & Ricco, G. (2023), 'Identification with External Instruments in Structural VARs', *Journal of Monetary Economics* **135**, 1–19.

Moser, C. & Rose, A. K. (2012), 'Why Do Trade Negotiations Take So Long?', *Journal of Economic Integration* **27**(2), 280–290.

Naik, N. Y. & Moore, M. J. (1996), 'Habit Formation and Intertemporal Substitution in Individual Food Consumption', *The Review of Economics and Statistics* **78**(2), 321–28.

Nekarda, C. J. & Ramey, V. A. (2020), 'The Cyclical Behavior of the Price-Cost Markup', *Journal of Money, Credit and Banking* **52**(S2), 319–353.

Novy, D. & Taylor, A. M. (2020), 'Trade and Uncertainty', *The Review of Economics and Statistics* **102**(4), 749–765.

Perotti, R. (2011), Expectations and Fiscal Policy: An Empirical Investigation, Working Papers 429, IGIER (Innocenzo Gasparini Institute for Economic Research), Bocconi University.

Peters, M. (2020), 'Heterogeneous Markups, Growth, and Endogenous Misallocation', *Econometrica* **88**(5), 2037–2073.

Plagborg-Møller, M. & Wolf, C. K. (2022), 'Instrumental Variable Identification of Dynamic Variance Decompositions', *Journal of Political Economy* **130**(8), 2164–2202.

Ramey, V. (2016), Chapter 2 - Macroeconomic Shocks and Their Propagation, *in* J. B. Taylor & H. Uhlig, eds, 'Handbook of Macroeconomics', Vol. 2, Elsevier, pp. 71–162.

Raval, D. & Rosenbaum, T. (2018), 'Why Do Previous Choices Matter for Hospital Demand? Decomposing

Switching Costs from Unobserved Preferences', *Review of Economics and Statistics* **100**(5), 906–915.

Ravn, M., Schmitt-Grohé, S. & Uribe, M. (2006), 'Deep Habits', *The Review of Economic Studies* **73**(1), 195–218.

Ravn, M., Schmitt-Grohé, S. & Uribe, M. (2010), 'Incomplete Cost Pass-Through under Deep Habits', *Review of Economic Dynamics* **13**(2), 317–332.

Rubio-Ramírez, J. F., Waggoner, D. F. & Zha, T. (2010), 'Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference', *Review of Economic Studies* **77**(2), 665–696.

Schmidt-Grohé, S. & Uribe, M. (2017), *Open Economy Macroeconomics*, Princeton, New Jersey: Princeton University Press.

Schmitt-Grohé, S. & Uribe, M. (2004), 'Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function', *Journal of Economic Dynamics and Control* **28**(4), 755–775.

Simonovska, I. (2015), 'Income Differences and Prices of Tradables: Insights from an Online Retailer', *Review of Economic Studies* **82**(4), 1612–1656.

Sims, C. A. (1980), 'Macroeconomics and Reality', *Econometrica* **48**(1), 1–48.

Staiger, R. W., Wolak, F. A., Litan, R. E., Katz, M. L. & Waverman, L. (1994), 'Measuring Industry-Specific Protection: Antidumping in the United States', *Brookings Papers on Economic Activity: Microeconomics* **1994**, 51–118.

Uhlig, H. (2005), 'What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure', *Journal of Monetary Economics* **52**(2), 381–419.

Online Appendix

to the paper titled "*Trade Shocks and the Transitional Dynamics of Markups*"
by Justas Dainauskas* and Povilas Lastauskas§

(Not For Publication)

* Reed College, 3203 SE Woodstock Blvd, Portland, OR 97202, USA, e-mail: justasd@reed.edu

§ International Monetary Fund, 700 19th Street N.W. Washington, DC 20431, USA and Homerton College, University of Cambridge, Cambridge, United Kingdom, e-mail: p.lastauskas@trinity.cantab.net.

A Theoretical Model

A.1 Expenditure Minimisation

The optimal demand for domestic and foreign varieties is derived by minimising the consumption expenditure subject to preferences:

$$\min_{\{X_{H,t}(\psi,\omega),\, X_{F,t}(\psi,\omega)\}} \quad P_t C_t(\psi) = \int_0^{\Omega} P_{H,t}(\omega) X_{H,t}(\psi,\omega) d\omega + \int_0^{\Omega^*} P_{F,t}(\omega) X_{F,t}(\psi,\omega) d\omega,$$

$$\text{s.t.} \quad C_t(\psi) = \left[\int_0^{\Omega} C_{H,t}(\psi,\omega)^{1-1/\eta} d\omega + \int_0^{\Omega^*} C_{F,t}(\psi,\omega)^{1-1/\eta} d\omega \right]^{1/(1-1/\eta)},$$

$$\text{s.t.} \quad C_{H,t}(\psi,\omega) = X_{H,t}(\psi,\omega) X_{H,t-1}(\omega)^{\theta},$$

$$\text{s.t.} \quad C_{F,t}(\psi,\omega) = X_{F,t}(\psi,\omega) X_{F,t-1}(\omega)^{\theta}.$$

The first-order conditions for H are given by

$$\text{FOC}(X_{H,t}(\psi,\omega))\text{: } P_t C_t(\psi)^{1/\eta} (X_{H,t}(\psi,\omega) X_{H,t-1}(\omega)^{\theta})^{-1/\eta} X_{H,t-1}(\omega)^{\theta} - P_{H,t}(\omega) = 0.$$

We can then write the population-wide demand for home variety ω consumed at home as

$$X_{H,t}(\omega) = \int_0^{\Psi} X_{H,t}(\psi,\omega) d\psi = \left[\frac{P_{H,t}(\omega)}{P_t} \right]^{-\eta} C_t X_{H,t-1}(\omega)^{\theta(\eta-1)}. \tag{A.1}$$

Analogous first-order conditions hold for foreign varieties.

A.2 Firms

A.2.1 labor Demand

The optimal labor demand is implied by the production technology:

$$X_{H,t}(\omega) = \phi[L_{H,t}(\omega) - \alpha] \qquad \Rightarrow \qquad L_{H,t}(\omega) = \alpha + \frac{X_{H,t}(\omega)}{\phi}. \tag{A.2}$$

Total costs: TC $:= W_t L_{H,t}(\omega) = W_t \alpha + W_t X_{H,t}(\omega) / \phi > 0$; average costs: AC $:= (W_t L_{i,t}(\omega)) / X_{i,t}(\omega) = (W_t \alpha) / X_{i,t}(\omega) + W_t / \phi > 0$; marginal costs: MC $:= \partial(W_t L_{i,t}(\omega)) / \partial X_{i,t}(\omega) = W_t / \phi > 0$.

A.2.2 Profit Maximisation

Firms choose prices and output that maximize the present discounted value of profits taking technology and demand for their variety as given. Foreign demand for home varieties is taken as given. Optimisation problem for home firms:

$$\max_{\{P_{H,t}(\omega),\, X_{H,t}(\omega)\}} \quad \mathbb{E}_t \sum_{\iota=0}^{\infty} \beta^{\iota} (P_{H,t+\iota}(\omega) X_{H,t+\iota}(\omega) - W_{t+\iota} L_{H,t+\iota}(\omega)),$$

$$\text{s.t.} \quad L_{H,t+\iota}(\omega) = \alpha + \frac{X_{H,t+\iota}(\omega)}{\phi},$$

$$\text{s.t.} \quad X_{H,t+\iota}(\omega) = \left[\frac{P_{H,t+\iota}(\omega)}{P_{t+\iota}} \right]^{-\eta} C_{t+\iota} X_{H,t+\iota-1}(\omega)^{\theta(\eta-1)}.$$

Current value *Lagrangian*:

$$\max_{\{P_{H,t}(\omega),\, X_{H,t}(\omega)\}} \quad \mathbb{E}_t \sum_{\iota=0}^{\infty} \beta^{\iota} \Bigg\{ P_{H,t+\iota}(\omega) X_{H,t+\iota}(\omega) - W_{t+\iota}\alpha - \frac{W_{t+\iota} X_{H,t+\iota}(\omega)}{\phi} \\ - \lambda_{H,t+\iota}(\omega) \left[X_{H,t+\iota}(\omega) - \left[\frac{P_{H,t+\iota}(\omega)}{P_{t+\iota}} \right]^{-\eta} C_{t+\iota} X_{H,t+\iota-1}(\omega)^{\theta(\eta-1)} \right] \Bigg\},$$

where $\lambda_{H,t+\iota} > 0$ is the *Lagrange* multiplier. First order conditions:

$$\text{FOC}(P_{H,t}(\omega))\text{: } X_{H,t}(\omega) - \frac{\eta \lambda_{H,t}(\omega) X_{H,t}(\omega)}{P_{H,t}(\omega)} = 0,$$

$$\text{FOC}(X_{H,t}(\omega))\text{: } P_{H,t}(\omega) - \frac{W_t}{\phi} - \lambda_{H,t}(\omega) + \theta\beta(\eta-1)\mathbb{E}_t \left[\frac{\lambda_{H,t+1}(\omega) X_{H,t+1}(\omega)}{X_{H,t}(\omega)} \right] = 0.$$

Combining and rearranging the above gives

$$\begin{aligned} P_{H,t}(\omega) &= \frac{W_t}{\phi} + \underbrace{\frac{P_{H,t}(\omega)}{\eta}}_{\lambda_{H,t}(\omega)} - \theta\beta(\eta-1)\mathbb{E}_t \left[\underbrace{\frac{P_{H,t+1}(\omega)}{\eta}}_{\lambda_{H,t+1}(\omega)} \frac{X_{H,t+1}(\omega)}{X_{H,t}(\omega)} \right], \\ &= \frac{W_t}{\phi} \left(\frac{\eta}{\eta-1} \right) \frac{P_{H,t}(\omega) X_{H,t}(\omega)}{P_{H,t}(\omega) X_{H,t}(\omega) + \theta\beta\mathbb{E}_t [P_{H,t+1}(\omega) X_{H,t+1}(\omega)]}. \end{aligned} \tag{A.3}$$

A.3 Equilibrium Conditions

A.3.1 Consumption

There is no international trade of financial assets. In financial autarky, the aggregate feasibility constraint requires that the aggregate consumption expenditure is equal to the aggregate wage bill:

$$\begin{aligned} \int_0^{\Psi} P_t C_t(\psi) d\psi &= \int_0^{\Psi}\int_0^{\Omega} P_{H,t}(\omega) X_{H,t}(\psi,\omega) d\omega d\psi + \int_0^{\Psi}\int_0^{\Omega^*} P_{F,t}(\omega) X_{F,t}(\psi,\omega) d\omega d\psi, \\ P_t C_t &= \int_0^{\Omega} P_{H,t}(\omega) X_{H,t}(\omega) d\omega + \int_0^{\Omega^*} P_{F,t}(\omega) X_{F,t}(\omega) d\omega, \\ &= \int_0^{\Omega} P_{H,t}(\omega) X_{H,t}(\omega) d\omega + \int_0^{\Omega} P^*_{H,t}(\omega) X^*_{H,t}(\omega) d\omega, \\ &= \underbrace{W_t}_{=1} \underbrace{\int_0^{\Omega} [L_{H,t}(\omega) + L^*_{H,t}(\omega)] d\omega}_{=L} \equiv L \qquad \Leftrightarrow \qquad C_t = \frac{L}{P_t}, \end{aligned} \tag{A.4}$$

where the second line imposes the goods market clearing conditions for each variety, such that $\int_0^{\Psi} X_{H,t}(\psi,\omega) d\psi = X_{H,t}(\omega)$ and $\int_0^{\Psi^*} X^*_{F,t}(\psi,\omega) d\psi = X^*_{F,t}(\omega)$, the third line assumes that trade is balanced at all times, such that $\int_0^{\Omega} P^*_{H,t}(\omega) X^*_{H,t}(\omega) d\omega = \int_0^{\Omega^*} P_{F,t}(\omega) X_{F,t}(\omega) d\omega$, and the fourth line invokes the free entry conditions $P_{H,t}(\omega) X_{H,t}(\omega) = W_t L_{H,t}(\omega)$ and $P^*_{H,t}(\omega) X^*_{H,t}(\omega) = W_t L^*_{H,t}(\omega)$, imposes the *numeraire* $W_t = 1$, and makes use of the labor market clearing condition (displayed).

A.3.2 Symmetric Import Penetration

Suppose all firms are equally productive, such that $\phi = \phi^* > 0$, incur identical iceberg costs, such that $\tau_t = \tau_t^* > 1$, face identical fixed costs $\alpha = \alpha^* > 0$, and are equally sized, such that $L = L^*$, $\Psi = \Psi^*$, and $\Omega = \Omega^*$. In this setting, home and foreign are perfectly symmetrical and balanced consistent with Krugman (1979). This is useful for two reasons. First, this implies that $P_{F,t} = P^*_{H,t} = \tau_t P_{H,t}$, $X_{H,t} = X^*_{F,t}$, and $X_{F,t} = X^*_{H,t}$, where the ω subscripts are dropped due to firm symmetry. Second, let $S_{F,t} = (P_{F,t}X_{F,t})/(P_t C_t) \equiv P_{F,t}X_{F,t}/L$ denote the home Import Penetration Ratio (IPR). It therefore follows that $S_{H,t} + S_{F,t} = 1$, $S_{F,t} = S^*_{H,t}$, and $S_{H,t} = 1 - S^*_{H,t}$.

A.3.3 Symmetric Price Markup

In the symmetric equilibrium, the price markup is identical across all home firms and given by

$$\frac{\phi P_{H,t}(\omega)}{W_t} \equiv \phi P_{H,t} = \left(\frac{\eta}{\eta - 1}\right) \frac{S_{H,t}}{S_{H,t} + \theta\beta\mathbb{E}_t[S_{H,t+1}]}, \tag{A.5}$$

where we make use of $P_{H,t}X_{H,t} = LS_{H,t}$ and $P_{H,t+1}X_{H,t+1} = LS_{H,t+1}$ from above.

A.3.4 Symmetric Output

Aggregate home output for home use:

$$X_{H,t} = \int_0^\Omega X_{H,t}(\omega)d\omega = \phi \int_0^\Omega [L_{H,t}(\omega) - \alpha]d\omega = \phi[L_{H,t} - \Omega\alpha]. \tag{A.6}$$

Substituting the free entry condition of $P_{H,t}X_{H,t} = W_t L_{H,t} \equiv L_{H,t}$ into the above and solving for either home price or output provides the additional equilibrium condition that pins down output:

$$P_{H,t} = \frac{\Omega\alpha}{X_{H,t}} + \frac{1}{\phi} \qquad \Leftrightarrow \qquad X_{H,t} = \frac{\Omega\alpha\phi}{\phi P_{H,t} - 1}. \tag{A.7}$$

A.3.5 Consumer Price Index

Observe that we can rewrite the recursive demand for each home variety (A.1) as

$$X_{H,t}(\omega)X_{H,t-1}(\omega)^\theta = \left[\frac{P_{H,t}(\omega)}{P_t X_{H,t-1}(\omega)^\theta}\right]^{-\eta} C_t. \tag{A.8}$$

Substituting this along with analogous expression for foreign varieties back into preferences and solving for the aggregate cost of living P_t gives

$$\begin{aligned}
C_t &= \left[\int_0^\Omega (X_{H,t}(\omega)X_{H,t-1}(\omega)^\theta)^{(\eta-1)/\eta}d\omega + \int_0^{\Omega^*} (X_{F,t}(\omega)X_{F,t-1}(\omega)^\theta)^{(\eta-1)/\eta}d\omega\right]^{\eta/(\eta-1)}, \\
1 &= \left[\int_0^\Omega \left[\frac{P_{H,t}(\omega)}{P_t X_{H,t-1}(\omega)^\theta}\right]^{1-\eta} d\omega + \int_0^{\Omega^*} \left[\frac{P_{F,t}(\omega)}{P_t X_{F,t-1}(\omega)^\theta}\right]^{1-\eta} d\omega\right]^{1/(1-\eta)}, \\
P_t &= \left[\int_0^\Omega \left(P_{H,t}(\omega)X_{H,t-1}(\omega)^{-\theta}\right)^{1-\eta} d\omega + \int_0^{\Omega^*} \left(P_{F,t}(\omega)X_{F,t-1}(\omega)^{-\theta}\right)^{1-\eta} d\omega\right]^{1/(1-\eta)}, \\
&= \left[P_{H,t}^{1-\eta}X_{H,t-1}^{\theta(\eta-1)} + P_{F,t}^{1-\eta}X_{F,t-1}^{\theta(\eta-1)}\right]^{1/(1-\eta)}.
\end{aligned} \tag{A.9}$$

Next, note that we can write

$$S_{H,t} = \frac{P_{H,t}X_{H,t}}{L} = \frac{\Omega\alpha}{L} + \frac{X_{H,t}}{L\phi} \qquad \Rightarrow \qquad X_{H,t-1} = \phi(S_{H,t-1}L - \Omega\alpha) \tag{A.10}$$

and

$$\begin{aligned} S_{F,t} = \frac{P_{F,t}X_{F,t}}{L} = \frac{\Omega\alpha}{L} + \frac{X_{F,t}}{L\phi} \qquad \Rightarrow \qquad X_{F,t-1} &= \phi(S_{F,t-1}L - \Omega\alpha), \\ &= \phi((1 - S_{H,t-1})L - \Omega\alpha). \end{aligned} \tag{A.11}$$

Then using this and the fact that $P_{F,t} \equiv P^*_{H,t} = \tau_t P_{H,t}$ we can rewrite the aggregate cost of living as

$$\begin{aligned} P_t = \left[P_{H,t}^{1-\eta}X_{H,t-1}^{\theta(\eta-1)} + P_{F,t}^{1-\eta}X_{F,t-1}^{\theta(\eta-1)}\right]^{1/(1-\eta)} &= P_{H,t}\left[X_{H,t-1}^{\theta(\eta-1)} + \tau_t^{1-\eta}X_{F,t-1}^{\theta(\eta-1)}\right]^{1/(1-\eta)}, \\ = \phi^{-\theta}P_{H,t}\left[(S_{H,t-1}L - \Omega\alpha)^{\theta(\eta-1)} + \tau_t^{1-\eta}((1 - S_{H,t-1})L - \Omega\alpha)^{\theta(\eta-1)}\right]^{1/(1-\eta)}&. \end{aligned} \tag{A.12}$$

Now suppose $\Omega\alpha = \gamma\bar{S}L$, where $0 < \gamma < 1$ and $\bar{S}$ is the steady state value of $S_{H,t} \equiv S^*_{F,t}$. Then using this and making use of $P_t = L/C_t$ we can obtain the following expression for real consumption:

$$\begin{aligned} \frac{L}{C_t} &= L\phi^{-\theta}P_{H,t}\left[(S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)} + \tau_t^{1-\eta}((1 - S_{H,t-1}) - \gamma\bar{S})^{\theta(\eta-1)}\right]^{1/(1-\eta)}, \\ \phi P_{H,t}C_t &= \phi^{1+\theta}\left[(S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)} + \tau_t^{1-\eta}((1 - S_{H,t-1}) - \gamma\bar{S})^{\theta(\eta-1)}\right]^{1/(\eta-1)}. \end{aligned} \tag{A.13}$$

A.3.6 Recursive Demand

Evaluating the recursive demand (A.1) in the symmetric equilibrium we can define

$$\begin{aligned} S_{H,t} = \frac{P_{H,t}X_{H,t}}{L} = \left(\frac{P_{H,t}}{P_t}\right)^{1-\eta}X_{H,t-1}^{\theta(\eta-1)} &= \left(\frac{P_{H,t}C_t}{L}\right)^{1-\eta}(L\phi)^{\theta(\eta-1)}(S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)}, \\ &= \left(\phi P_{H,t}C_t\right)^{1-\eta}(L\phi)^{(1+\theta)(\eta-1)}(S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)}. \end{aligned} \tag{A.14}$$

A.3.7 Canonical Representation

Gathering the above results leads to the following canonical representation of the model:

$$\text{PP:}\ \phi P_{H,t} = \left(\frac{\eta}{\eta - 1}\right)\frac{S_{H,t}}{S_{H,t} + \theta\beta\mathbb{E}_t\left[S_{H,t+1}\right]}, \tag{A.15}$$

$$\text{SS:}\ S_{H,t} = \left(\phi P_{H,t}C_t\right)^{1-\eta}(L\phi)^{(1+\theta)(\eta-1)}(S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)}, \tag{A.16}$$

$$\text{CC:}\ \phi P_{H,t}C_t = \phi^{1+\theta}\left[(S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)} + \tau_t^{1-\eta}(1 - S_{H,t-1} - \gamma\bar{S})^{\theta(\eta-1)}\right]^{1/(\eta-1)}. \tag{A.17}$$

Now let $\phi P_{H,t} := \mu_t$, $S_{H,t} := s_t$, and $C_t := c_t$. The model can therefore be expressed as:

$$\text{PP:}\quad \mu_t = \left(\frac{\eta}{\eta - 1}\right)\frac{s_t}{s_t + \theta\beta\mathbb{E}_t\left[s_{t+1}\right]}, \tag{A.18}$$

$$\text{SS:}\quad s_t = (\mu_t c_t)^{1-\eta}(s_{t-1} - \gamma\bar{s})^{\theta(\eta-1)}(L\phi)^{(1+\theta)(\eta-1)}, \tag{A.19}$$

$$\text{CC:}\quad \mu_t c_t = \phi^{1+\theta}\left[(s_{t-1} - \gamma\bar{s})^{\theta(\eta-1)} + \tau_t^{1-\eta}(1 - s_{t-1} - \gamma\bar{s})^{\theta(\eta-1)}\right]^{1/(\eta-1)}, \tag{A.20}$$

$$\text{TT:}\quad \tau_t = (1 - \rho)\bar{\tau} + \rho\tau_{t-1} + \sigma\varepsilon_t. \tag{A.21}$$

A.4 Steady State

In the steady state, $s = \bar{s}$ and $p = \bar{p} = \bar{\mu}/\phi$, where $\bar{s}$ and $\bar{\mu} > 1$ are calibrated constants. This restricts the value of $\eta > 1$, but $\theta > 0$ is chosen freely. To see this, consider PP at the steady state:

$$\bar{\mu} = \left(\frac{\eta}{\eta - 1}\right)\frac{1}{1+\theta\beta} \qquad \Rightarrow \qquad \eta = \frac{\bar{\mu}(1+\theta\beta)}{\bar{\mu}(1+\theta\beta)-1} > 1, \tag{A.22}$$

where $\{\bar{\mu}, \theta, \beta\}$ are calibrated. Second, consider rearranging CC at the steady state as follows:

$$\bar{\mu}\bar{c} = \phi^{1+\theta}\underbrace{\left[((1-\gamma)\bar{s})^{\theta(\eta-1)} + \bar{\tau}^{1-\eta}(1-(1+\gamma)\bar{s})^{\theta(\eta-1)}\right]^{1/(\eta-1)}}_{=\Xi^{1/(\eta-1)}} \quad \Leftrightarrow \quad \bar{c} = \frac{\Xi^{1/(\eta-1)}\phi^{1+\theta}}{\bar{\mu}} > 0. \tag{A.23}$$

This implies that $(\bar{\mu}\bar{c})^{1-\eta}\phi^{(1+\theta)(\eta-1)} = \Xi^{-1}$. Substituting this into SS pins down L as follows:

$$\bar{s} = (\bar{\mu}\bar{c})^{1-\eta}(L\phi)^{(1+\theta)(\eta-1)}((1-\gamma)\bar{s})^{\theta(\eta-1)} \quad \Leftrightarrow \quad L = \left[\frac{\Xi}{(1-\gamma)^{\theta(\eta-1)}\bar{s}^{\theta(\eta-1)-1}}\right]^{1/[(1+\theta)(\eta-1)]}. \tag{A.24}$$

For completeness, the steady state of output comes from the zero profit condition: $\bar{x} = L\phi(1-\gamma)\bar{s}$. Hence, $\bar{c}$, L, and Ξ are all decreasing in $\bar{\tau}$, such that higher long-run iceberg costs leads to lower consumption and less labor supply in the long-run equilibrium albeit it is fixed in the short-run.

B Solution Method: Unanticipated Shocks

The PP-SS-CC-TT model is a system of non-linear stochastic difference equations. A closed-form solution to this system does not exist, but there exists an approximate numerical solution. Following Schmitt-Grohé & Uribe (2004), we solve the model using linear approximation of the equilibrium conditions around the non-stochastic steady state using a first-order Taylor series expansion.

The solution method starts by re-stating the equilibrium conditions in compact form:

$$\mathbb{E}_t[f(\mathbf{y}_{t+1}, \mathbf{y}_t, \mathbf{x}_{t+1}, \mathbf{x}_t)] = 0, \tag{B.1}$$

where $f(\cdot)$ is the *policy function*, while $\mathbf{y}_{t+1}$, $\mathbf{y}_t$, $\mathbf{x}_{t+1}$, $\mathbf{x}_t$ are the forward-looking and contemporaneous vectors of *control* and *state* variables, respectively. Specifically, $\mathbf{x}_t = [s_t, \tau_t]$ is a 2×1 vector and $\mathbf{y}_t = [\mu_t, c_t, s_t, s_t^a]'$ is a 4×1 vector, where s_t^a is an auxiliary variable.[20] The first-order Taylor series expansion of the policy function around the steady state is given by:

$$f_{\mathbf{y}'}\mathbb{E}_t[\hat{\mathbf{y}}_{t+1}] + f_{\mathbf{y}}\hat{\mathbf{y}}_t + f_{\mathbf{x}'}\mathbb{E}_t[\hat{\mathbf{x}}_{t+1}] + f_{\mathbf{x}}\hat{\mathbf{x}}_t = 0, \tag{B.2}$$

where $\hat{\mathbf{y}}_{t+1} = \mathbf{y}_{t+1} - \mathbf{y}$, $\hat{\mathbf{y}}_t = \mathbf{y}_t - \mathbf{y}$, $\hat{\mathbf{x}}_{t+1} = \mathbf{x}_{t+1} - \mathbf{x}$, and $\hat{\mathbf{x}}_t = \mathbf{x}_t - \mathbf{x}$ measure the absolute deviations of the control and state variables from the steady state, and $f_{\mathbf{y}'} = \partial f/\partial \mathbf{y}_{t+1}|_{\mathbf{y}_{t+1}=\mathbf{y}}$, $f_{\mathbf{y}} = \partial f/\partial \mathbf{y}_t|_{\mathbf{y}_t=\mathbf{y}}$, $f_{\mathbf{x}'} = \partial f/\partial \mathbf{x}_{t+1}|_{\mathbf{x}_{t+1}=\mathbf{x}}$, $f_{\mathbf{x}} = \partial f/\partial \mathbf{x}_t|_{\mathbf{x}_t=\mathbf{x}}$ are the matrices of policy function partial derivatives evaluated at the steady state. The solution to this linearized system is then defined as the law of motion for the state variables and the terminal condition for the control variables, respectively:

$$\hat{\mathbf{x}}_{t+1} = \mathscr{B}\hat{\mathbf{x}}_t + \mathbf{\Sigma}\varepsilon_{t+1}, \quad \text{for} \quad t = \{0, 1, 2, ..., T-1\} \tag{B.3}$$

$$\hat{\mathbf{y}}_t = \mathscr{A}\hat{\mathbf{x}}_t, \quad \text{for} \quad t = 1, 2, 3, ..., T, \tag{B.4}$$

[20]The import penetration ratio s_t is both forward-looking and backward-looking, such that it is both a control and a state variable (i.e., *mixed*). As per usual in perturbation methods, this is addressed by introducing an auxiliary variable and an auxiliary equation to the model, namely $\mathbb{E}_t[s_{t+1}] = s_t^a$.

where $\mathbf{\Sigma}$ is a scalar, ε_{t+1} is the stochastic shock to the iceberg costs, while $\mathscr{B}$ and $\mathscr{A}$ are the 2×2 and 4×4 matrices, respectively, that are conditional on the calibrated parameters and calculated numerically from the analytical partial derivatives $f_{\mathbf{y}'}$, $f_{\mathbf{y}}$, $f_{\mathbf{x}'}$, and $f_{\mathbf{x}}$. In what follows, we show how the $\mathscr{B}$ and $\mathscr{A}$ matrices are derived, explain how the saddle-path stable solution is obtained, and show how that is used to calculate the impulse response functions.

B.1 State-Space Derivations

Let $\mathbf{A} = [f_{\mathbf{x}'}, f_{\mathbf{y}'}]$, $\mathbf{B} = -[f_{\mathbf{x}}, f_{\mathbf{y}}]$, and $\mathbf{w}_t = [\hat{\mathbf{x}}_t', \hat{\mathbf{y}}_t']'$, such that the first-order approximation to the linearized system of equations can be written as

$$\mathbf{A}\mathbb{E}_t[\mathbf{w}_{t+1}] = \mathbf{B}\mathbf{w}_t. \tag{B.5}$$

Notice that $\mathbf{A}$ and $\mathbf{B}$ are *square* matrices (i.e., the number of rows is equal to the number of columns). Consider the generalized Schur decomposition of $\mathbf{A}$ and $\mathbf{B}$ as follows:

$$\mathbf{a} = \mathbf{q}\mathbf{A}\mathbf{z}, \tag{B.6}$$

$$\mathbf{b} = \mathbf{q}\mathbf{B}\mathbf{z}, \tag{B.7}$$

such that $\mathbf{a}$ and $\mathbf{b}$ are upper-triangular matrices (i.e., all elements below the main diagonal are equal to zero), while $\mathbf{q}$ and $\mathbf{z}$ are both orthonormal matrices (i.e., $\mathbf{q}'\mathbf{q} = \mathbf{q}\mathbf{q}' = \mathbf{z}'\mathbf{z} = \mathbf{z}\mathbf{z}' = \mathcal{I}$, where $\mathcal{I}$ is an identity matrix). Let $\mathbf{v}_t = \mathbf{z}'\mathbf{w}_t$. Then it follows that

$$\mathbf{A}\mathbb{E}_t[\mathbf{w}_{t+1}] = \mathbf{B}\mathbf{w}_t \quad \Rightarrow \quad \underbrace{\mathbf{q}\mathbf{A}\mathbf{z}}_{\mathbf{a}}\ \underbrace{\mathbf{z}'\mathbb{E}_t[\mathbf{w}_{t+1}]}_{\mathbb{E}[\mathbf{v}_{t+1}]} = \underbrace{\mathbf{q}\mathbf{B}\mathbf{z}}_{\mathbf{a}}\ \underbrace{\mathbf{z}'\mathbf{w}_t}_{\mathbf{v}_t} \quad \Rightarrow \quad \mathbf{a}\mathbb{E}_t[\mathbf{v}_{t+1}] = \mathbf{b}\mathbf{v}_t. \tag{B.8}$$

The Schur transformation of the linear system of difference equations is useful is because $\mathbf{b}_{ii}/\mathbf{a}_{ii}$ measures the *generalized eigenvalue* of matrices $\mathbf{A}$ and $\mathbf{B}$, where subscript ii indicates the i'th diagonal element of the matrix. Following the seminal contribution of Blanchard & Kahn (1980), generalized eigenvalues are used to determine whether or not a linear system of difference equations characterized by rational expectations is saddle-path stable. Klein (2000) further generalizes the solution approach and states that if there are as many generalized eigenvalues whose absolute value is less than one as the number of state variables, then there is one unique time path for the entire system to converge to the deterministic steady state (i.e., saddle-path stability). But when there are less (more) generalized eigenvalues whose absolute value is less than one than the number of state variables, then the system is deemed unstable (indeterminate), such that there are none (infinitely many) time paths for the system to converge.

The next part eliminates equilibria that are inadmissible (i.e., non-convergent). Recall that the model contains 2 state variables. Suppose that

$$\mathbf{a} = \begin{bmatrix} \mathbf{a}_{11} & \mathbf{a}_{12} \\ \mathbf{0} & \mathbf{a}_{22} \end{bmatrix}, \quad \mathbf{b} = \begin{bmatrix} \mathbf{b}_{11} & \mathbf{b}_{12} \\ \mathbf{0} & \mathbf{b}_{22} \end{bmatrix}, \quad \mathbf{z} = \begin{bmatrix} \mathbf{z}_{11} & \mathbf{z}_{12} \\ \mathbf{z}_{21} & \mathbf{z}_{22} \end{bmatrix}, \quad \mathbf{v}_t = \begin{bmatrix} \mathbf{v}_{1,t} \\ \mathbf{v}_{2,t} \end{bmatrix}, \tag{B.9}$$

where $\mathbf{a}_{11}$ and $\mathbf{b}_{11}$ are 2×2 matrices, whose diagonals do indeed generate generalized eigenvalues of $\mathbf{A}$ and $\mathbf{B}$ with absolute values that are less than one, whereas $\mathbf{a}_{22}$ and $\mathbf{b}_{22}$ are square matrices, whose diagonals generate generalized eigenvalues with absolute values greater than one. Then because $\mathbf{a}$ and $\mathbf{b}$ are upper-triangular, it follows that

$$\mathbf{a}_{22}\mathbb{E}_t[\mathbf{v}_{2,t+1}] = \mathbf{b}_{22}\mathbf{v}_{2,t}. \tag{B.10}$$

At this point, we know that $\mathbf{b}_{22}$ is invertible, since (i) each diagonal element of $\mathbf{b}_{22}$ is non-zero; and (ii) $\mathbf{b}_{22}$ is upper-triangular. Consequently,

$$\mathbf{v}_{2,t} = \mathbf{b}_{22}^{-1}\mathbf{a}_{22}\mathbb{E}_t[\mathbf{v}_{2,t+1}] \equiv \mathbf{0}, \tag{B.11}$$

since $\mathbf{b}_{22}^{-1}\mathbf{a}_{22}$ generates eigenvalues that are less than unity in modulus. This statement is unambiguously true, since (i) the inverse of a non-singular upper-triangular matrix is upper-triangular; (ii) the product of two upper-triangular matrices is also upper-triangular; and (iii) the eigenvalues of an upper-triangular matrix are the diagonal elements. Consequently, the only way to ensure that the system of difference equations is non-explosive is to impose $\mathbf{v}_{2,t} = 0$, which rules out the non-convergent equilibria and implies that

$$\mathbf{a}\mathbb{E}_t[\mathbf{v}_{t+1}] = \mathbf{b}\mathbf{v}_t \quad \Rightarrow \quad \begin{bmatrix} \mathbf{a}_{11} & \mathbf{a}_{12} \\ \mathbf{0} & \mathbf{a}_{22} \end{bmatrix} \begin{bmatrix} \mathbb{E}_t[\mathbf{v}_{1,t+1}] \\ \mathbf{0} \end{bmatrix} = \begin{bmatrix} \mathbf{b}_{11} & \mathbf{b}_{12} \\ \mathbf{0} & \mathbf{b}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{v}_{1,t} \\ \mathbf{0} \end{bmatrix}, \tag{B.12}$$

which means that

$$\mathbf{a}_{11}\mathbb{E}_t[\mathbf{v}_{1,t+1}] = \mathbf{b}_{11}\mathbf{v}_{1,t} \quad \Rightarrow \quad \mathbb{E}_t[\mathbf{v}_{1,t+1}] = \mathbf{a}_{11}^{-1}\mathbf{b}_{11}\mathbf{v}_{1,t}. \tag{B.13}$$

Using result (B.11) it follows that

$$\begin{bmatrix} \mathbf{v}_{1,t} \\ \mathbf{0} \end{bmatrix} = \mathbf{v}_t = \mathbf{z}'\mathbf{w}_t = \begin{bmatrix} \mathbf{z}_{11} & \mathbf{z}_{12} \\ \mathbf{z}_{21} & \mathbf{z}_{22} \end{bmatrix}' \begin{bmatrix} \hat{\mathbf{x}}_t \\ \hat{\mathbf{y}}_t \end{bmatrix} = \begin{bmatrix} \mathbf{z}_{11}'\hat{\mathbf{x}}_t + \mathbf{z}_{21}'\hat{\mathbf{y}}_t \\ \mathbf{z}_{12}'\hat{\mathbf{x}}_t + \mathbf{z}_{22}'\hat{\mathbf{y}}_t \end{bmatrix}, \tag{B.14}$$

which gives us the terminal condition

$$\mathbf{z}_{12}'\hat{\mathbf{x}}_t + \mathbf{z}_{22}'\hat{\mathbf{y}}_t = \mathbf{0} \quad \Rightarrow \quad \hat{\mathbf{y}}_t = \underbrace{-\mathbf{z}_{22}'^{-1}\mathbf{z}_{12}}_{\mathscr{A}}\,\hat{\mathbf{x}}_t \equiv \mathscr{A}\hat{\mathbf{x}}_t, \tag{B.15}$$

where $\mathbf{z}_{22}'$ is invertible, since $\mathbf{z}'$ is orthonormal. Then using result B.15, we can show that

$$\mathbf{v}_{1,t} = \mathbf{z}_{11}'\hat{\mathbf{x}}_t + \mathbf{z}_{21}'\hat{\mathbf{y}}_t = \mathbf{z}_{11}'\hat{\mathbf{x}}_t \underbrace{-\mathbf{z}_{21}'\mathbf{z}_{22}'^{-1}\mathbf{z}_{12}\hat{\mathbf{x}}_t}_{\mathbf{z}_{21}'\hat{\mathbf{y}}_t} = (\mathbf{z}_{11}' - \mathbf{z}_{21}'\mathbf{z}_{22}'^{-1}\mathbf{z}_{12})\hat{\mathbf{x}}_t \equiv \mathbf{z}_{11}'^{-1}\hat{\mathbf{x}}_t. \tag{B.16}$$

where the last statement follows from the fact that $\mathbf{z}$ is orthonormal. See Schmidt-Grohé & Uribe (2017) footnote 6 on page 121 for algebraic details. Finally, substituting result B.16 into B.13 gives the law of motion for the state variables in conditional expectation

$$\mathbf{a}_{11}\mathbf{z}_{11}^{-1}\mathbb{E}_t[\hat{\mathbf{x}}_{t+1}] = \mathbf{b}_{11}\mathbf{z}_{11}^{-1}\hat{\mathbf{x}}_t \quad \Rightarrow \quad \mathbb{E}_t[\hat{\mathbf{x}}_{t+1}] = \underbrace{\mathbf{z}_{11}\mathbf{a}_{11}^{-1}\mathbf{b}_{11}\mathbf{z}_{11}^{-1}}_{\mathscr{B}}\,\hat{\mathbf{x}}_t = \mathscr{B}\hat{\mathbf{x}}_t. \tag{B.17}$$

The *transversality condition* thus holds, such that $\lim_{\iota\to\infty}\mathbb{E}_t[\mathbf{w}_{t+\iota}] = \mathbf{w}_0$, where $\iota = \{0, 1, 2, ...\}$ and $\mathbf{w}_0$ denotes the deterministic steady state of $\mathbf{w}_t$.

B.2 Impulse Response Functions

The impulse response functions measure the deviation of an arbitrary variable from the deterministic steady state over time as implied by the system of difference equations when it is disturbed by an arbitrarily chosen value for the stochastic shock ε_t. The impulse response functions for the state variables are derived as follows:

$$\mathrm{IRF}(\hat{\mathbf{x}}_{t+\iota}) = \mathbb{E}_t[\hat{\mathbf{x}}_{t+\iota}] - \mathbb{E}_{t-1}[\hat{\mathbf{x}}_{t+\iota}] = \mathscr{B}^\iota\mathbb{E}_t[\hat{\mathbf{x}}_t] - \mathscr{B}^\iota\mathbb{E}_{t-1}[\hat{\mathbf{x}}_t] \equiv \mathscr{B}^\iota\boldsymbol{\Sigma}\varepsilon_t, \tag{B.18}$$

since $\hat{\mathbf{x}}_{t+\iota} = \mathscr{B}\hat{\mathbf{x}}_{t+\iota-1} + \boldsymbol{\Sigma}\varepsilon_{t+\iota}$ and $\mathbb{E}_{t-1}[\varepsilon_{t+\iota}] = \mathbf{0}$ for all $\iota = \{0, 1, 2, ...\}$. Similarly, the impulse response functions for the control variables are derived as follows:

$$\mathrm{IRF}(\hat{\mathbf{y}}_{t+\iota}) = \mathbb{E}_t[\hat{\mathbf{y}}_{t+\iota}] - \mathbb{E}_{t-1}[\hat{\mathbf{y}}_{t+\iota}] = \mathscr{A}\{\mathbb{E}_t[\hat{\mathbf{x}}_{t+\iota}] - \mathbb{E}_{t-1}[\hat{\mathbf{x}}_{t+\iota}]\} \equiv \mathscr{A}\mathscr{B}^\iota\boldsymbol{\Sigma}\varepsilon_t, \tag{B.19}$$

since $\hat{\mathbf{y}}_t = \mathscr{A}\hat{\mathbf{x}}_t$, where $\iota = \{0, 1, 2, ...\}$.

C Solution Method: Anticipated Shocks

Suppose the shock to iceberg costs $\{\varepsilon_t\}_{t=1}^{T}$ for integer $1 < T < \infty$ is known from date $t = 1$ onwards. At date $t = 1$, the shock is unanticipated, but from then onwards, all firms and individuals acquire *perfect foresight*. Following Laffargue (1990), Boucekkine (1995), and Juillard (1996), under this assumption, the canonical PP-SS-CC-TT model can be cast in the following compact form:

$$f(\mathbf{s}_{t+1}, \mathbf{s}_t, \mathbf{s}_{t-1}, \varepsilon_t) = 0, \tag{C.1}$$

where $\mathbf{s}_t = [\mu_t, s_t, c_t, \tau_t]$ is a 4×1 vector state and control variables. Suppose $\mathbf{s}_0$ (i.e., the *initial conditions*) and $\mathbf{s}_T$ (i.e., the *terminal conditions*) are known. The solution is then characterized as time paths of all variables $\mathbf{S} = [\mathbf{s}'_1, \mathbf{s}'_2, ..., \mathbf{s}'_T]$ that satisfy the above at each time period, such that

$$F(\mathbf{S}) = 0, \tag{C.2}$$

where $F(\cdot)$ is a function parametrized by the deep parameters $(\beta, \phi, \mu, \gamma, \bar{s}, \bar{\tau}, \sigma, \rho, \theta)$, the initial conditions $(\mathbf{s}_0)$, and the terminal conditions $(\mathbf{s}_T)$. Because $\mathbf{S}$ is *ex-ante* unknown by construction, the goal is to find its values iteratively until $F(\mathbf{S}) = 0$ is satisfied using an initial guess $\mathbf{S}^{(0)}$. Suppose $J(\mathbf{S}) = \nabla_{\mathbf{S}} F(\mathbf{S})$ denotes the $4T \times 4T$ matrix (i.e the *Jacobian*). Assuming that $\mathbf{S}^{(\iota-1)}$ is given for $\iota = \{1, 2, ..., \bar{I}\}$, we take the first-order Taylor series expansion of $F(\mathbf{S}^{(\iota)}) = 0$ around a fixed point $\mathbf{S}^{(\iota-1)}$, which gives rise to the so-called *secant* equation: $F(\mathbf{S}^{(\iota)}) \simeq F(\mathbf{S}^{(\iota-1)}) + J(\mathbf{S}^{(\iota)})(\mathbf{S}^{(\iota)} - \mathbf{S}^{(\iota-1)})$. Since we are looking for $\mathbf{S}^{(\iota)}$, such that $F(\mathbf{S}^{(\iota)}) = 0$, we can impose this requirement and obtain the following *Newton-Raphson* sequential updating rule:

$$\mathbf{S}^{(\iota)} = \mathbf{S}^{(\iota-1)} - J(\mathbf{S}^{(\iota)})^{-1} F(\mathbf{S}^{(\iota-1)}). \tag{C.3}$$

In practice, the algorithm is deemed to have converged when $||F(\mathbf{S}^{\iota})|| < \epsilon$, where $\epsilon > 0$ denotes infinitesimal convergence criterion. The convergence of the *Newton-Raphson* algorithm is further improved by imposing *homotopy* in the sequential updating rule:

$$\mathbf{S}^{(\iota)} = \delta \mathbf{S}^{(\iota-1)} + (1-\delta)\left[\mathbf{S}^{(\iota-1)} - J(\mathbf{S}^{(\iota)})^{-1} F(\mathbf{S}^{(\iota-1)})\right] = \mathbf{S}^{(\iota-1)} - (1-\delta) J(\mathbf{S}^{(\iota)})^{-1} F(\mathbf{S}^{(\iota-1)}). \tag{C.4}$$

for some arbitrary value of $0 < \delta < 1$, usually in the neighbourhood of unity. Observe that the $4T \times 4T$ Jacobian matrix $J(\mathbf{S})$ is subject to the *curse of dimensionality*. This means that the total number of elements increases quadratically with the length of the vector $\mathbf{s}_t$ and the number of time periods $T > 0$. To circumvent computational difficulties, observe that the Jacobian matrix is *sparse*, since the number of non-zero elements increases linearly with the length of $\mathbf{s}_t$ and the size of $T > 0$.[21] To see this, let $f(\mathbf{s}_{t+1}, \mathbf{s}_t, \mathbf{s}_{t-1}, \varepsilon_t) = f_t$ and note that the PP-SS-CC-TT model contains only one lead $\mathbf{s}_{t+1}$ and one lag $\mathbf{s}_{t-1}$ at any time period, which implies that

$$J(\mathbf{S}) = \begin{bmatrix} \frac{\partial f_1}{\partial \mathbf{s}_1} & \frac{\partial f_1}{\partial \mathbf{s}_2} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \cdots & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} \\ \frac{\partial f_2}{\partial \mathbf{s}_1} & \frac{\partial f_2}{\partial \mathbf{s}_2} & \frac{\partial f_3}{\partial \mathbf{s}_3} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \cdots & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} \\ \mathbf{0}_{4\times4} & \frac{\partial f_3}{\partial \mathbf{s}_2} & \frac{\partial f_3}{\partial \mathbf{s}_3} & \frac{\partial f_3}{\partial \mathbf{s}_4} & \mathbf{0}_{4\times4} & \cdots & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots \\ \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \cdots & \frac{\partial f_{T-2}}{\partial \mathbf{s}_{T-3}} & \frac{\partial f_{T-2}}{\partial \mathbf{s}_{T-2}} & \frac{\partial f_{T-2}}{\partial \mathbf{s}_{T-1}} & \\ \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \cdots & \mathbf{0}_{4\times4} & \frac{\partial f_{T-1}}{\partial \mathbf{s}_{T-2}} & \frac{\partial f_{T-1}}{\partial \mathbf{s}_{T-1}} & \frac{\partial f_{T-1}}{\partial \mathbf{s}_T} \\ \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \cdots & \mathbf{0}_{4\times4} & \mathbf{0}_{4\times4} & \frac{\partial f_T}{\partial \mathbf{s}_{T-1}} & \frac{\partial f_T}{\partial \mathbf{s}_T} \end{bmatrix}. \tag{C.5}$$

[21]Traditionally, due to the curse of dimensionality, the Jacobian in its entirety is not inverted and not stored. Instead, $\mathbf{S}$ is solved for each iteration recursively by substituting out the Jacobian in the secant equation, which requires storing only its non-zero elements (see Laffargue (1990), Boucekkine (1995), and Juillard (1996)). But we calculate the inverse and store the Jacobian in its entirety by exploiting the sparse matrix algebra libraries that are now widely available. This proves to be both simpler and less computationally demanding.

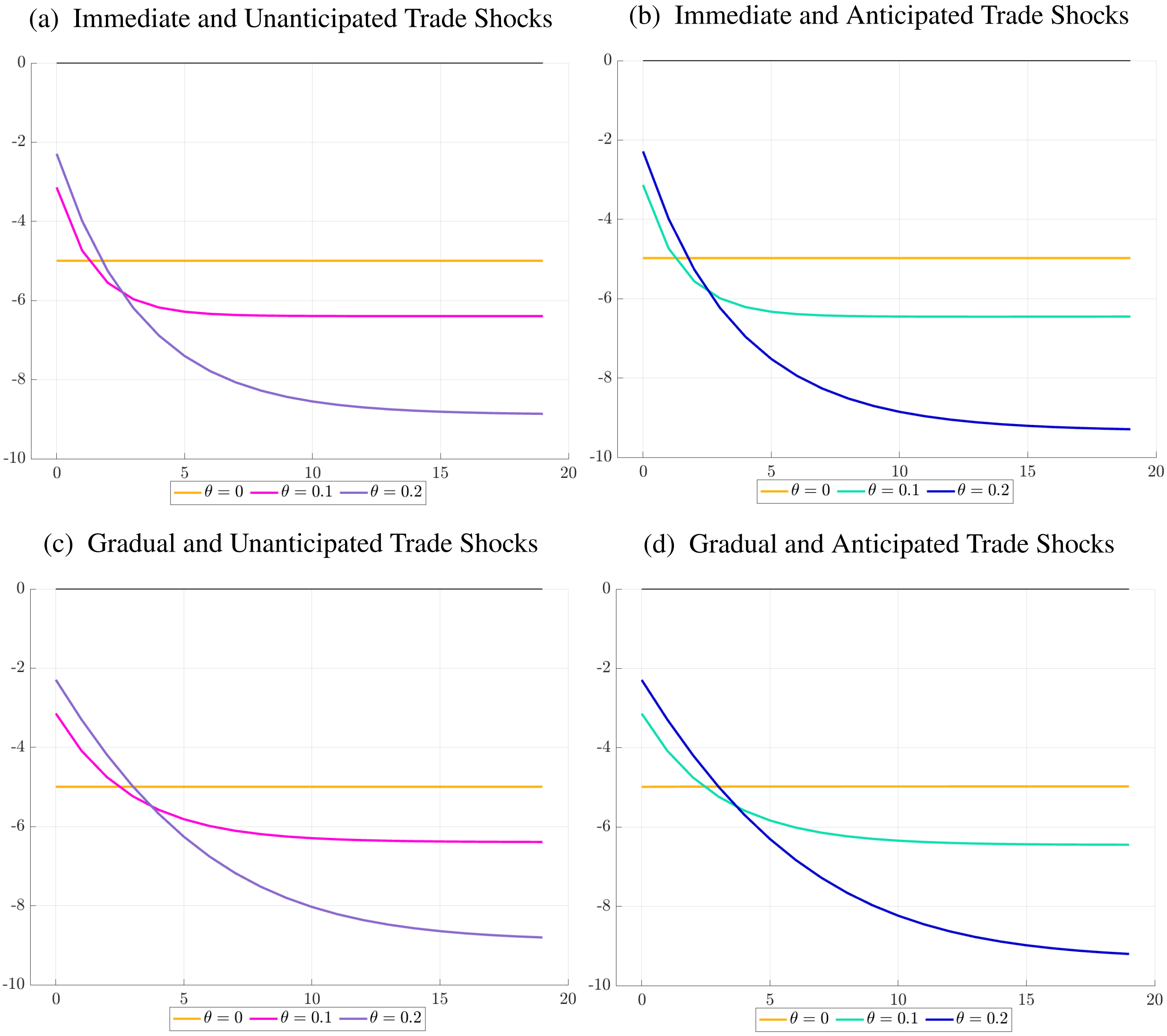
D Dynamic Trade Elasticity

The trade elasticity is the key statistic used to assess the welfare gains from trade (see Anderson & van Wincoop (2004), Arkolakis et al. (2012), Imbs & Mejean (2015), Feenstra et al. (2018), Boehm et al. (2023)). It measures the percentage change in the value bilateral trade flows due to a percentage change in trade costs. Arkolakis et al. (2012) famously show that in a wide class of static trade models, the trade elasticity is constant and equal to $1 - \eta < 0$, where $\eta > 1$ is the *Armington elasticity*. However, recent empirical evidence shows that trade elasticity is dynamic and increasing (in absolute value) over time, such that in the short-run, trade flows are less responsive to trade costs than in the long-run (Alessandria et al. (2021), Boehm et al. (2023)).

Figure 4 presents the theoretical estimates of the trade elasticity under a wide range of parameterisations our the model. We find that without habits $\theta = 0$, the trade elasticity is constant, independent of shock sequencing or anticipation, and equal to around -5. This is a value that corresponds closely to the traditional static trade elasticity estimates (e.g. Anderson & van Wincoop (2004), Arkolakis et al. (2012), Imbs & Mejean (2015)). With habits $\theta > 0$ and immediate shock sequencing $\rho = 0$, our model generates a dynamic trade elasticity that is in many ways consistent with the empirical evidence. Specifically, with intense habits $\theta = 0.2$, the trade elasticity upon impact is around -2.15, which is less than one-half the size of the static trade elasticity. But as time passes after the shock, the trade elasticity eventually rises to around -9, which is a little less than double the size of the static trade elasticity. These estimates are somewhat greater (in absolute size) than those obtained by Boehm et al. (2023), but it can be explained by the fact that we calibrate the value of the Armington elasticity to the magnitude that is typically used in the trade literature, whereas Armington elasticity in macroeconomics is typically calibrated to just above unity (see Imbs & Mejean (2015) for a discussion). Lower values of the Armington elasticity helps us fit the empirical trade elasticity dynamics better, but at the same time it makes it more difficult to compare the welfare outcomes in our model to those in the existing trade literature.

With less intense habits $\theta = 0.1$, the trade elasticity is still increasing over time (in absolute size) qualitatively, but quantitatively it is somewhat closer to the magnitude of the static trade elasticity. With habits $\theta > 0$ and gradual shocks $0 < \rho < 1$, the short-run and long-run trade elasticity is exactly the same as when shocks are immediate, but in the medium-run the trade elasticity is somewhat lower (in absolute size). Crucially, because demand for imports and by extension the import penetration ratio in our model are both purely-backward looking, expectations of future trade policy shocks have no impact on the magnitude of the trade elasticity. Consequently, the trade elasticity dynamics are virtually identical whether shocks are anticipated or unanticipated and any marginal numerical discrepancies in our results reflect negligible approximation errors.

Figure 4: Dynamic Trade Elasticity



The vertical axes measure the magnitude of the trade elasticity and the horizontal axes denote discrete time periods after the shocks to the iceberg costs. We calculate the trade elasticities numerically using the dynamic responses presented in Figures 2 and 3. Consistent with Alessandria et al. (2021), we first calculate the trade elasticity upon the initial impact of the shock to the iceberg costs, namely $e_0 = [\ln((1-s_0)/s_0) - \ln((1-\bar{s})/\bar{s})]/[\ln(\tau_0) - \ln(\bar{\tau})]$. Then we study how the trade elasticity evolves over time by calculating the cumulative sum $\bar{e}_h = e_0 + \Delta e_1 + \Delta e_2 + \cdots + \Delta e_h = e_0 + \sum_{\iota=1}^{h} \Delta e_\iota$. Each subplot in this figure presents our estimates of the cumulative trade elasticity $\bar{e}_h$. Consistent with the previous parametrisations, if shocks to the iceberg costs are immediate (gradual), we set $\rho = 0$ ($\rho = 0.7$).

E Annex

Table 3: Data Description

Variable	Description	Source
MKP_t	Price Markup: consistent with the De Loecker & Warzynski (2012) framework, it is measured as the inverse of the labor share in the private business sector using data from the Bureau of Labor Statistics (BLS). Under the assumption of the Cobb-Douglas production function, this is equivalent to value added divided by total labor compensation. However, our preferred specification also adjusts for overhead labor (i.e., it is measured as the log of current dollar output in private business divided by the wage bill for variable labor). Time coverage: Q1 1960 – Q4 2017.	Nekarda & Ramey (2020)
CON_t	Consumption: personal consumption expenditures at constant prices (*Billions of Chained 2012 Dollars, Seasonally Adjusted Annual Rate, PCECC96*). Time coverage: Q1 1960 – Q3 2020.	Federal Reserve Economic Data
TRF_t	Import Tariffs: calculated from the nominal customs data (*Federal government current tax receipts, taxes on production and imports: Customs duties, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate, B235RC1Q027SBEA*) and nominal imports data (*Imports of Goods and Services, Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate, IMPGS*) as a ratio between customs duties and imports less customs duties. Time coverage: Q1 1960 – Q3 2020.	Federal Reserve Economic Data and own calculations
IPR_t	Import Penetration Ratio: ratio between imports as a percentage of total domestic demand, where domestic demand is GDP minus exports plus imports. Imports of goods and services (*Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate, IMPGSC1*), GDP (*Billions of Chained 2012 Dollars, Seasonally Adjusted Annual Rate, GDPC1*), and exports of goods and services (*Billions of Chained 2012 Dollars,Quarterly, Seasonally Adjusted Annual Rate, EXPGSC1*). Time coverage: Q1 1960 – Q3 2020.	Federal Reserve Economic Data and own calculations
IPRC_t and IPRI_t	Consumption- and Industrial-Composition Based IPRs: based on imports of consumer goods except food and automotive (*Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate, A652RC1Q027SBEA*) and imports of industrial supplies and materials (*Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate, LA0000041Q027SBEA*). Domestic demand is defined the same as above. Time coverage: Q1 1967 – Q3 2020.	Federal Reserve Economic Data and own calculations
TTB_t and TTBN_t	Temporary Trade Barriers: the TTBA series measures the value of U.S. temporary trade barrier initiations on imports in terms of 2018 U.S. dollars adjusted for macro factors using basic OLS regressions, extracting the residuals, and standardising. The TTBN series reweighs the value of each TTB initiation by the extent of media coverage measured by the number of mentions in the Financial Times. Time coverage: Q2 1988 – Q4 2015.	Metiu (2021)

Table 4: Selected Trade Policy Changes (Event-Based Identification Strategy)

Episode	Description	Anticipated?	Protectionism?
Nixon Shock **August 1971 (Q3)**	A secretive meeting at Camp David between President Richard Nixon, FED chairman Arthur Burns, and other high-ranking officials aimed at addressing concerns over rising inflation. Actions: (1) suspension of USD convertibility to gold; (2) executive order imposing wage and price freezes; and (3) a 10% surcharge (i.e., tariff) on all dutiable imports.	no	yes
Ford Shock **January 1975 (Q1)**	State of the Union address during which President Gerald Ford announces new measures to combat the quadrupling oil prices and all-round energy crisis. Actions: (1) corporate and income tax cuts; (2) public sector pay rise ceilings; (3) subsidising U.S. oil, natural gas, nuclear and coal power production; and (4) oil fees (i.e., tariffs) on all imports of oil and petroleum products;	no	yes
Protectionist Legislation Talks **September 1985 (Q3)**	The emergence of "New Wave" trade protectionism as a replacement of the free trade doctrine. Major newspapers quotes commentary from experts, such as Paul Krugman (MIT), Roger E. Brinner (Data Resources Inc.), Robert Z. Lawrence (Brookings Institution), John M. Culbertson (University of Wisconsin), and others.	yes	yes
Trade Sanctions on Japan **April 1987 (Q2)**	President Ronald Reagan announces targeted tariffs on Japanese computers, colour television sets, and power hand tools worth 300mln in 1987 U.S. dollars. The sanctions are viewed as a temporary retaliatory measure against below-cost dumping of Japanese semiconductors to other countries. Semiconductors themselves are excluded from the sanctions list.	no	yes
Presidential Campaign Oil Import Fee Discussions **February 1988 (Q1)**	Prior to accepting the Presidential Nomination at the Republican National Convention in August 1988, the republican presidential candidate at the time George Bush expresses commitment to reducing U.S. dependence on foreign oil.	yes	yes
Trade War with Europe over Farm Subsidies **November 1992 (Q4)**	U.S. imposes a 200% tariff on European white wine. Spearheaded by Clayton Yeutter, the U.S. Secretary of Agriculture under President George Bush, following several years of retaliatory threats against the European Community farm subsidies concerning all agricultural produce.	no	yes

Oil Import Fee Discussed; Clinton Takes Office **February 1993 (Q1)**	Expectations are high that then President-elect Bill Clinton intends to work on some energy-related tax after he takes office. Many independent petroleum producers in Oklahoma and elsewhere are promoting the oil import fee as their preferred option. President-elect comments that he has not yet made any decision on the energy tax.	yes	yes
Congress Passes NAFTA **November 1993 (Q4)**	Inception dates back to 1988 when the Canada-United States Free Trade Agreement was passed after which Mexican President Carlos Salinas de Gortari decided to approach President George Bush to propose a similar agreement. Diplomatic negotiations began in 1990 and the leaders of the three nations signed the agreement in December 1992. The agreement is finally ratified by all three nations in November 1993.	yes	no
NAFTA Enforced **January 1994 (Q1)**	President Clinton signed NAFTA into law on the 8th of December 1993 and it suddenly came into force on the 1st of January 1994. 96% of NAFTA's tariff reductions were known at least one year in advance. Broadly, goods were classified into 5 categories: class A to be immediately zeroed; classes B, C and C+ to be phased out over 5, 10 and 15 years, respectively; and class D already had zero tariffs before NAFTA.	no	no
Uncertainty in the Senate over Passing GATT **December 1994 (Q4)**	Endorsed by President Bill Clinton, the U.S. House of Representative passes an expansion of the original GATT (est. 1947) in bipartisan spirit. The bill passes less than a month after Senate Republican Leader Robert Dole expresses he wants a vote that year on the U.S. membership in the newly proposed World Trade Organisation provided the U.S. could easily get out.	no	no
Tariff Threat on Japanese Automobiles **June 1995 (Q2)**	U.S. White House issues an ultimatum to Japan to ease entry for U.S. autos and auto parts or face prohibitive tariffs on $5.9 billion worth of luxury auto sales in the United States. The Clinton administration set the deadline to the 28th of June for the imposition of 100% percent tariffs on 13 Japanese luxury automobile models if Japan refuses. The move caps 20 months of fruitless negotiations. The automotive sector accounts for 60 percent of a $66 billion U.S. trade deficit with Japan.	yes	yes
Bush Imposes Steel Tariffs **March 2002 (Q1)**	George Bush administration placed tariffs of 10-30% percent on over 170 steel products imported from abroad in an attempt to protect the U.S. steel industry from foreign dumping. These temporary tariffs were set to last for three years and official investigations were announced back in 2001 (Q2).	yes	yes

WTO Penalizes Steel Tariffs **November 2003 (Q4)**	The World Trade Organization ruled that U.S. steel tariffs imposed by President George Bush were illegal, clearing the way for the European Union to impose more than $2 billion of sanctions on imports from the United States unless Washington quickly drops the duties. President Bush removed steel tariffs in December 2003.	no	no
U.S. Presidential Election **November 2016 (Q4)**	The Democratic Party nominee Hillary Clinton opposes the Trans-Pacific Partnership (TPP), while the Republican Party nominee Donald Trump threatens tariffs on China and Mexico.	yes	yes
Tariff Threat on Mexico; Trump Takes Office **January 2017 (Q1)**	Excerpt from Donald Trump's inauguration speech: "*Every decision on trade, on taxes, on immigration, on foreign affairs will be made to benefit American workers and American families. We must protect our borders from the ravages of other countries making our products, stealing our companies and destroying our jobs. Protection will lead to great prosperity and strength. [...] We will bring back our jobs. We will bring back our borders...*"	yes	yes
Section 232 Investigations **April 2017 (Q2)**	On the 19th of April 2017, the U.S. Secretary of Commerce Wilbur Ross initiates an investigation under section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. 1862), to determine the effects on the national security of imports of steel. Under circumstances deemed threatening to the national security, it authorizes the President to adjust imports of an article and its derivatives.	yes	yes
GOP Tax Plan Debates Import Tax **July 2017 (Q3)**	Top G.O.P. tax negotiators move closer to a unified plan. One of the proposed changes is the so-called "border-adjustment tax" that would tax imports and let exports go untaxed. Shortly after the discussions, the Speaker of the House Paul Ryan gives up on the border-adjustment tax plan.	yes	yes
USITC Recommends Safeguards for Solar and Washing Machines **November 2017 (Q4)**	President Donald Trump decides whether to impose tariffs and/or quotas on South Korea, Malaysia, Japan, Mexico, Thailand, and Vietnam that could affect $8.5 billion of imports of solar panels and $1.8 billion of imports of washing machines. Under Section 201 of the Trade Act of 1974, the U.S. International Trade Commission (USITC) completed its investigation and in both cases found that U.S. companies were injured by imports, giving the President the authority to impose new trade barriers.	yes	yes

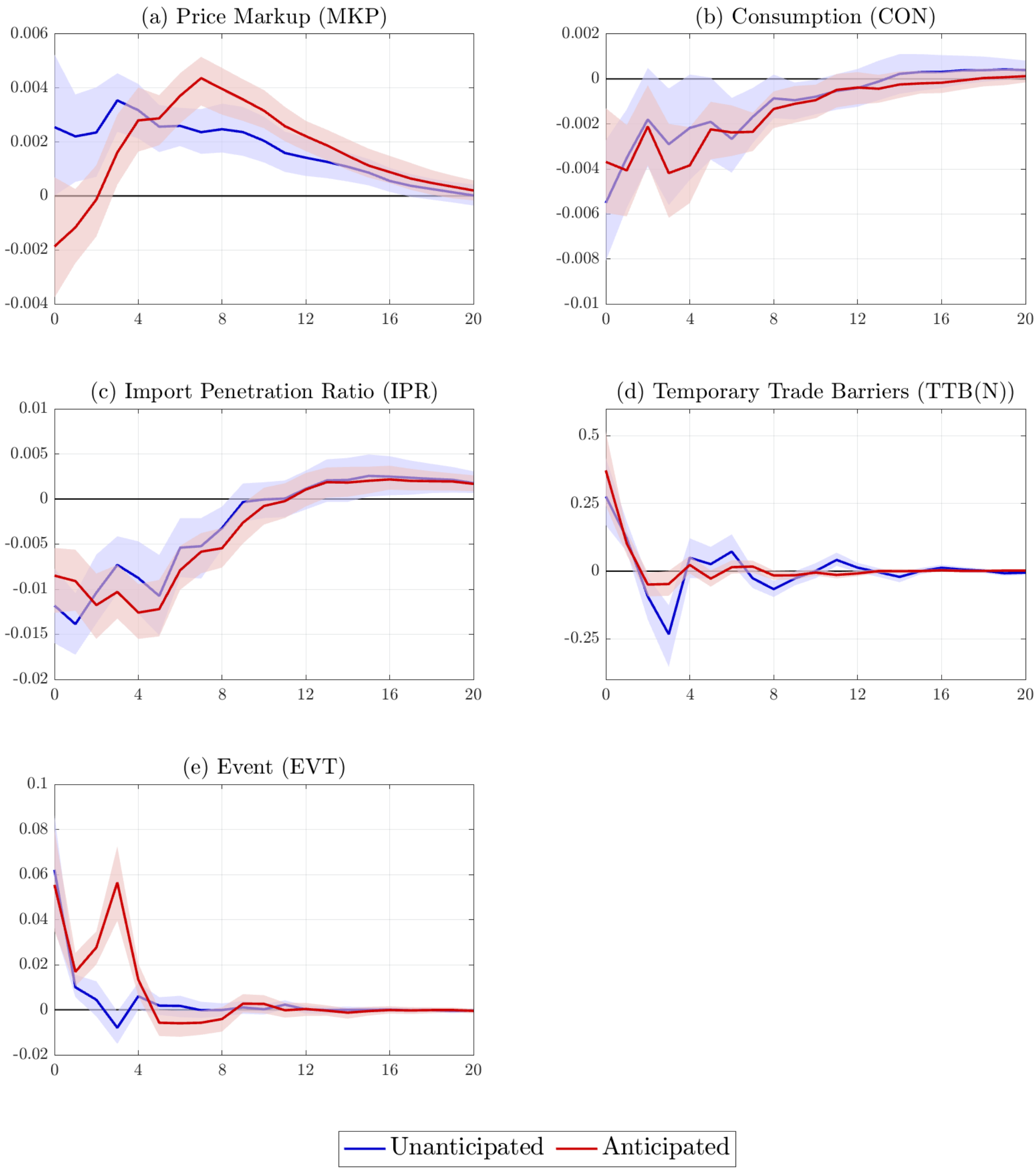
Tariffs on Solar Panels and Washing Machines **January 2018 (Q1)**	President Donald Trump imposes a 20% tariff on the first 1.2m imported large residential washers in the first year, and a 50% tariff on machines above that number. The tariffs decline to 16% and 40%, respectively, in the third year. A 30% tariff is imposed on imported solar cells and modules in the first year, with tariffs declining to 15% by the fourth year. The tariff allows 2.5 gigawatts of unassembled solar cells to be imported tariff-free in each year.	no	yes
Announced Tariffs on Steel and Aluminium **March 2018 (Q1)**	President Donald Trump restricts imports of steel and aluminium in response to investigations under Section 232 of the Trade Expansion Act of 1962, led by Commerce Secretary Wilbur Ross. Concluding that metal imports threatened national security, on the 1st of March 2018, the President announced tariffs of 25% on imports of steel and 10% on imports of aluminium. Some tariffs were imposed as early as 23rd of March 2018.	no	yes
Tariffs on Chinese Goods **July 2018 (Q3)**	On the 22nd of March 2018, President Donald Trump signs a memorandum under the Section 301 of the Trade Act of 1974, instructing the United States Trade Representative (USTR) to apply tariffs of $50 billion on Chinese goods. Following retaliatory threats, on the 15th of June 2018 President Donald Trump releases a list of $34 billion of Chinese goods to face a 25% tariff, starting on the 6th of July 2018. Another list with $16 billion of Chinese goods was released, with an implementation date of 23rd of August 2018.	no	yes
New Tariff Threats on Mexico **June 2019 (Q2)**	President Donald Trump announces that he is placing a 5% tariff on all Mexican imports to pressure the country to do more to curb immigration. The tariff would gradually increase "until illegal immigration problem is remedied".	yes	yes

This table classifies anticipated and/or protectionist trade policy changes based on the description of events obtained from the Trade Policy Uncertainty (TPU) Database (Caldara et al. (2020)). Two events from the database are excluded, namely: (1) June 2016 Brexit referendum; and (2) December 2018 stock market collapse. In addition, we separate the ratification and actual implementation of NAFTA into two separate events. Given that the U.S. ratified and implemented the first round of NAFTA tariff reductions within the first 40 days, but some of the tariffs took up to 15 years to phase out, we argue that NAFTA corresponds to an unanticipated and gradual trade shock.

F Robustness Checks and Additional Results

F.1 Fewer Sign Restrictions

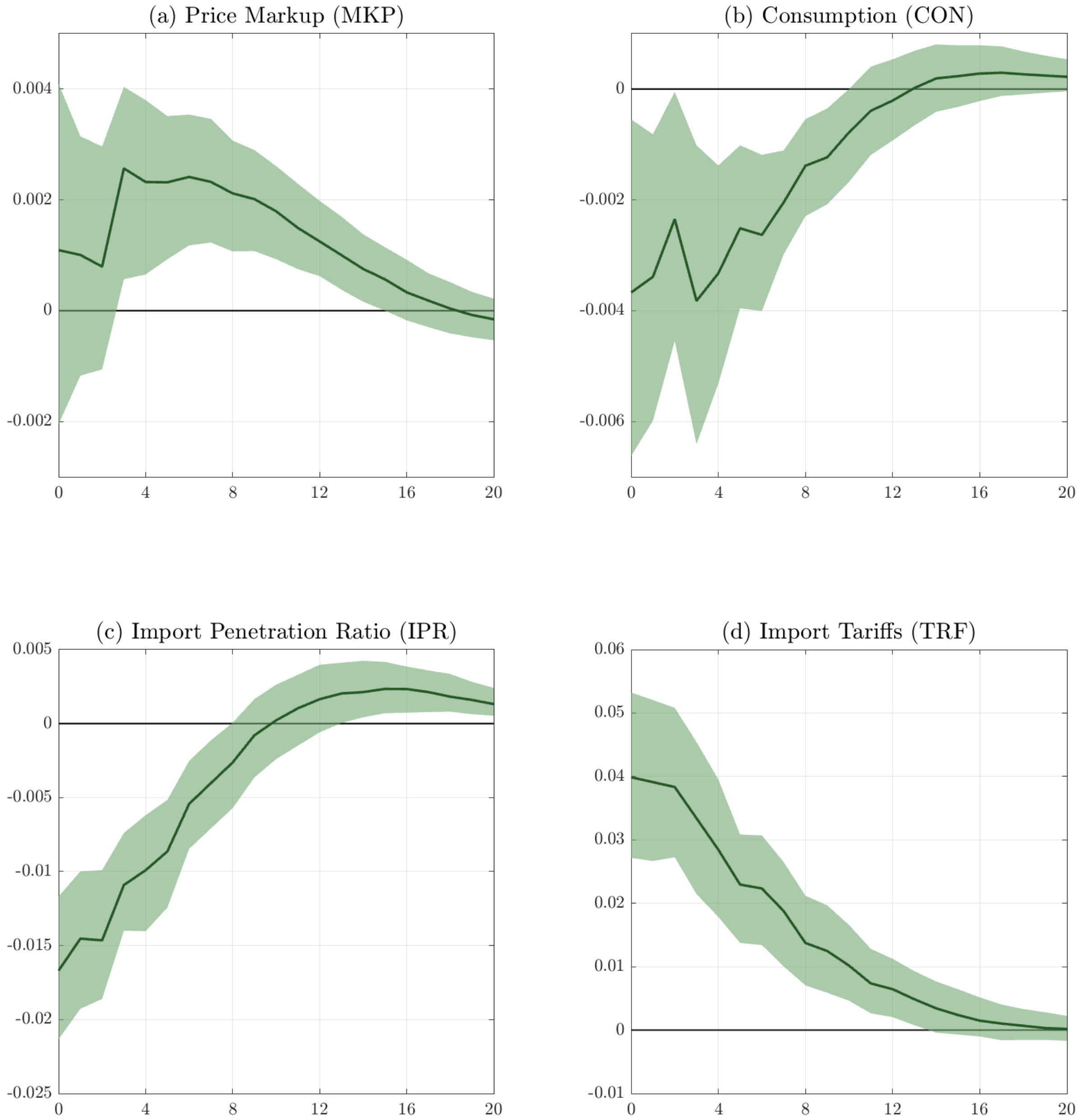
Figure 5: Non-Cumulative Impulse Responses to Anticipated and Unanticipated Trade Protectionist Shocks Identified using Sign Restrictions, Historical Events, Media Coverage, and Temporary Trade Barrier Announcements (w/o Consumption Sign-Restriction)



The vertical axis measures the sign-restricted *non-cumulative* impulse responses in terms of log changes in the cyclical component (except for dummy variable EVT and TTB(N)). The horizontal axis measures the time horizon $h = \{0, 1, 2, \ldots\}$. The standardized residuals of the TTB induced trade value and news-weighted trade value series adjusted for serial correlation come directly from Metiu (2021) and are not logged or de-trended. The cyclical components of all other time series are obtained using the Hamilton (2018) filter. The results are based on the Bayesian SVAR model with a lag order of 4 quarters and sign restrictions on TTB induced trade value and news-weighted trade value, IPR, and consumption that hold for two consecutive quarters after the shock (i.e., $\mathcal{H} = 1$). Solid lines are the point-wise posterior medians. The shaded areas outline the 68-percent credible sets, which is standard in Bayesian econometrics. Each figure is based on 1000 independent draws of parameters from posterior distributions.

F.2 No Narratives / Only Sign Restrictions

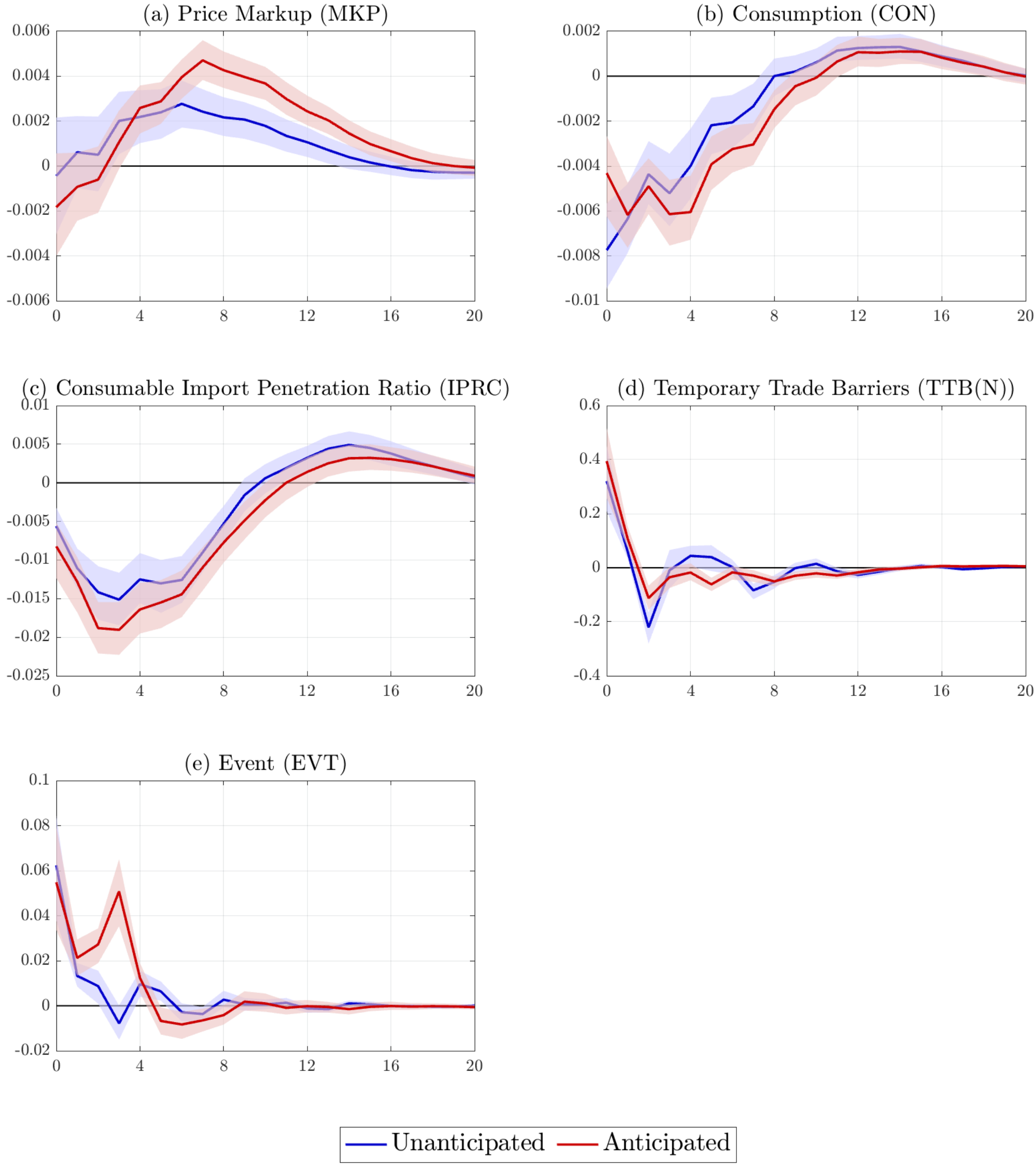
Figure 6: Non-Cumulative Impulse Responses to Unanticipated and Anticipated Trade Protection Shocks Identified using Sign Restrictions and Customs Duty-Based Import Tariff Shock



The vertical axis measures the sign-restricted *non-cumulative* impulse responses in terms of log changes in the cyclical component. The horizontal axis measures the time horizon $h = \{0, 1, 2, \ldots\}$. The shock is induced to the aggregate import tariff revenue as a percentage of total import demand, which is logged or de-trended. The cyclical components of all other time series are obtained using the Hamilton (2018) filter. The results are based on the Bayesian SVAR model with a lag order of 4 quarters and sign restrictions on TTB induced trade value and news-weighted trade value, IPR, and consumption that hold for two consecutive quarters after the shock (i.e., $\mathcal{H} = 1$). Solid lines are the point-wise posterior medians. The shaded areas outline the 68-percent credible sets, which is standard in Bayesian econometrics. Each figure is based on 1000 independent draws of parameters from posterior distributions.

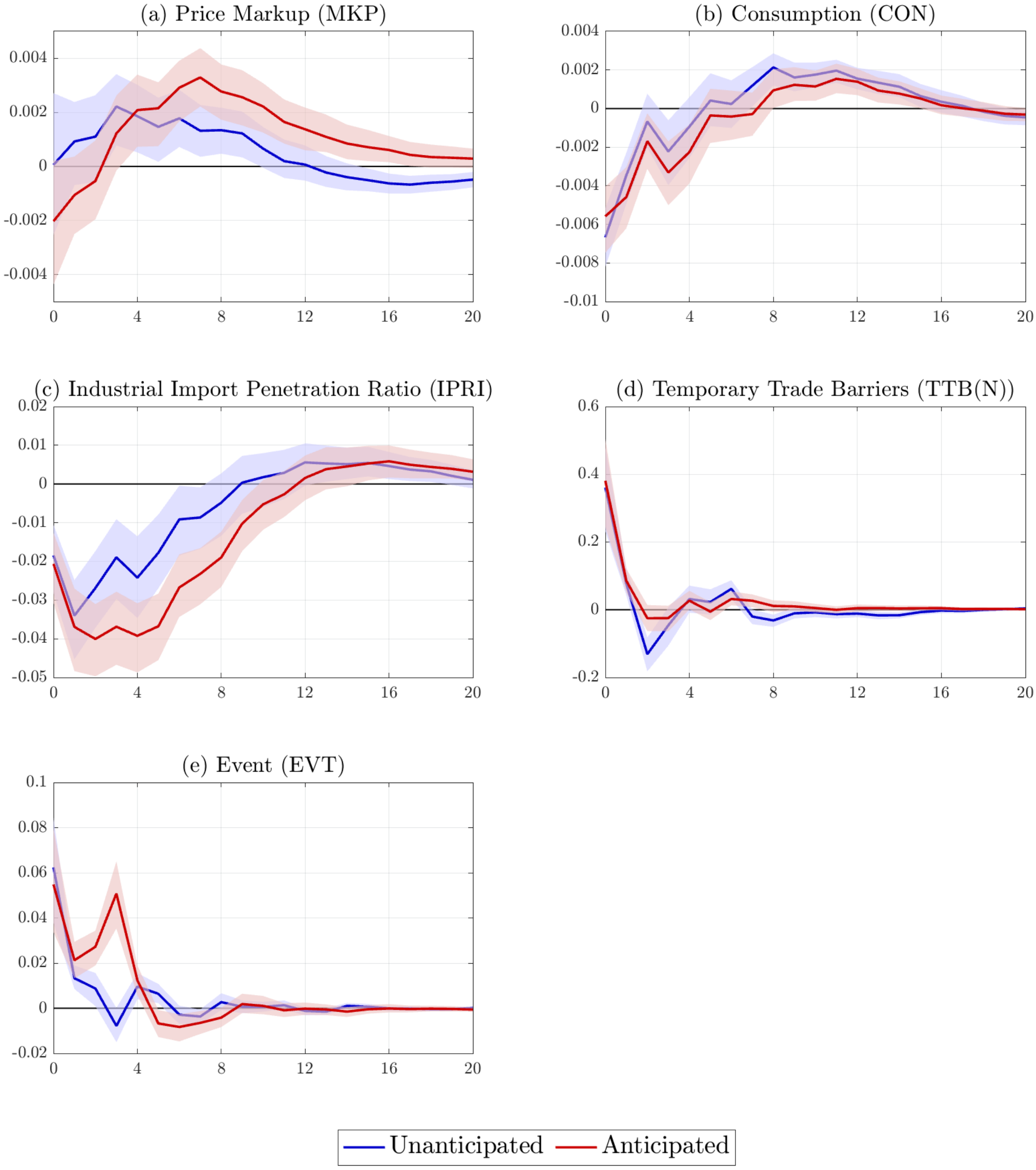
F.3 Consumable vs Industrial Imports

Figure 7: Non-Cumulative Impulse Responses to Anticipated and Unanticipated Trade Protectionist Shocks Identified using Sign Restrictions, Historical Events, Media Coverage, and Temporary Trade Barrier Announcements (Consumable IPR)



The vertical axis measures the sign-restricted *non-cumulative* impulse responses in terms of log changes in the cyclical component (except for dummy variable EVT and TTB(N)). The horizontal axis measures the time horizon $h = \{0, 1, 2, \ldots\}$. The standardized residuals of the TTB induced trade value and news-weighted trade value series adjusted for serial correlation come directly from Metiu (2021) and are not logged or de-trended. The cyclical components of all other time series are obtained using the Hamilton (2018) filter. The results are based on the Bayesian SVAR model with a lag order of 4 quarters and sign restrictions on TTB induced trade value and news-weighted trade value, IPRC, and consumption that hold for two consecutive quarters after the shock (i.e., $\mathcal{H} = 1$). Solid lines are the point-wise posterior medians. The shaded areas outline the 68-percent credible sets, which is standard in Bayesian econometrics. Each figure is based on 1000 independent draws of parameters from posterior distributions.

Figure 8: Non-Cumulative Impulse Responses to Anticipated and Unanticipated Trade Protectionist Shocks Identified using Sign Restrictions, Historical Events, Media Coverage, and Temporary Trade Barrier Announcements (Industrial IPR)



The vertical axis measures the sign-restricted *non-cumulative* impulse responses in terms of log changes in the cyclical component (except for dummy variable EVT and TTB(N)). The horizontal axis measures the time horizon $h = \{0, 1, 2, \ldots\}$. The standardized residuals of the TTB induced trade value and news-weighted trade value series adjusted for serial correlation come directly from Metiu (2021) and are not logged or de-trended. The cyclical components of all other time series are obtained using the Hamilton (2018) filter. The results are based on the Bayesian SVAR model with a lag order of 4 quarters and sign restrictions on TTB induced trade value and news-weighted trade value, IPRI, and consumption that hold for two consecutive quarters after the shock (i.e., $\mathcal{H} = 1$). Solid lines are the point-wise posterior medians. The shaded areas outline the 68-percent credible sets, which is standard in Bayesian econometrics. Each figure is based on 1000 independent draws of parameters from posterior distributions.