Strategic Managers with Noisy Beliefs: Evidence from Carbon Pricing*

Kenza Benhima† Andreas Fuster‡

Sébastien Houde§ Heiner Mikosch¶

Abstract

We study how strategic interactions and noisy beliefs determine managers' expectations about the impacts of a given macroeconomic shock in a general equilibrium setting. We propose a novel identification strategy based on a survey instrument designed to recover primitives governing firm managers' strategic interactions and beliefs. We apply our approach to the context of carbon pricing reform in Switzerland and find that a CHF 100 per ton carbon tax increase is expected to reduce output by 1.14% over a short- to medium-run horizon; that firms hold overly pessimistic beliefs about the economy-wide impact of carbon pricing; and that quantity setting tends to exhibit strategic substitutabilities, dampening the impact of noisy beliefs. Information counterfactuals show that removing the excess pessimism from aggregate public signals would reduce the expected output decline by about 40%, and by 30% when we take strategic substitutabilities into account.

*We thank seminar participants at the Université Libre de Bruxelles, Ghent University, HEC Lausanne, and VUA-RWI Behavioral and Environmental Economics Workshop for helpful comments. Funding from the E4S Center and the MTEC Foundation is gratefully acknowledged. The survey and pre-analysis plan were pre-registered on the AEA RCT Registry (AEARCTR-0013609). We received ethics approval from the ETH Zurich Ethics Commission (EK-2024-N-196).

†HEC Lausanne, University of Lausanne; CEPR. Email: kenza.benhima@unil.ch.

‡École Polytechnique Fédérale de Lausanne (EPFL); Swiss Finance Institute; CEPR. Email: andreas.fuster@epfl.ch.

§HEC Lausanne, University of Lausanne; CESifo. Email: sebastien.houde@unil.ch.

¶ETH Zurich, KOF Swiss Economic Institute. Email: mikosch@kof.ethz.ch.

1 Introduction

This paper examines how strategic firm interactions and managers' noisy beliefs determine expectations about the impacts of a macroeconomic shock or a policy reform. The central premise is simple. A manager contemplating the impacts of a macroeconomic shock must form expectations not only about the direct impact on their own firm, but also about the general-equilibrium response of competitors and demand conditions. These general-equilibrium effects can be summarized as a strategic game in which firms' optimal choices depend, in part, on beliefs about others' choices. As a consequence, firms' responses to a shock are jointly determined by (i) managers' beliefs about their respective firm's direct shock elasticity, (ii) beliefs about other firms' elasticity, and (iii) the intensity and sign of strategic interactions. Beliefs about the economy-wide elasticity can influence firms' beliefs about their own elasticity but also about other firms' elasticity. In turn, strategic interactions shape how managers' pessimistic or optimistic beliefs about the economy translate into firm-level expectations. Whether equilibrium outcomes are strategic complements or substitutes, strategic interactions amplify or dampen noisy beliefs, respectively.

Empirically, assessing these mechanisms through ex-ante analyses based solely on observational data poses several challenges. It typically requires strong identifying variation, rich firm-level data (often released with substantial lags), and structural assumptions about production technologies and market structure. As a result, it is often difficult, if not impossible, to provide timely evidence to policymakers about the expected impacts of an upcoming change in economic conditions or a policy reform. To overcome these limitations, we propose a vignette survey experiment to elicit managers' expectations directly and recover firm-specific primitives—such as perceived own and cross-firm elasticities—that govern strategic interactions and noisy beliefs in a general-equilibrium setting. Crucially, the approach yields a set of sufficient statistics that requires minimal assumptions about the production structure of the economy, allowing for counterfactual policy simulations.

We apply our approach to the context of carbon pricing reform in Switzerland, a timely and highly debated topic. Switzerland was among the first countries to adopt a broad-based carbon pricing scheme, doing so in 2008. In recent years, several referendums have addressed alternative measures to meet Switzerland's

climate goals. Notably, a 2021 initiative to expand the coverage and level of the carbon tax was narrowly defeated at the polls. Among analysts, there is now renewed interest in identifying ways to make such proposals more politically acceptable. Investigating firm managers' beliefs about carbon pricing policy could therefore play an important role in informing this debate.

Our identification strategy to recover firm-specific primitives is built around three scenarios that vary the scope of a carbon tax reform. Namely, managers need to form expectations about the impacts of an economy-wide, sector-wide, and firm-specific carbon pricing scheme over a medium-run horizon—3 years in our setting. In addition, we need to elicit managers' own planned production impact, and, for some but not all scenarios, expectation of sectoral production impact, and expectation of aggregate production impact (with natural restrictions for the sectoral and firm-specific scenarios). Our design allows us to identify: (i) the relevant tax semi-elasticity (beliefs about the quantity impact of carbon pricing); (ii) strategic interaction parameters capturing how a firm's own quantity choices respond to expected sectoral and aggregate changes; and (iii) noisy beliefs about the policy's sectoral and aggregate production impacts.

Our main findings can be summarized as follows. First, the survey-based identification strategy is feasible in practice: managers respond meaningfully to the scenarios, allowing us to recover firm-specific primitives. Second, managers perceive sizable output costs of carbon taxation: in our baseline scenario, a CHF 100/ton increase in the carbon tax is associated with an expected decline in aggregate output of around 1.14% after three years. Third, we find evidence of *overly pessimistic beliefs* about how the rest of the economy responds to the tax, compared to the average firms' beliefs about their own impact. This evidence suggests that firms receive excessively negative signals about the aggregate cost elasticity. Last, but not least, we find strong strategic substitutabilities in quantity setting, especially at the sectoral level: managers lower their optimal production response when they expect stronger activity by other firms in their sector, consistent with competitive interactions within sectors. In turn, strategic substitutabilities *dampen* the impact of their pessimistic beliefs about carbon pricing on their own outcomes.

Motivated by this evidence, we enrich the model with an information structure where firms observe some private signal of their own elasticity, and public signals about the aggregate and sectoral elasticity that can be driven respectively by aggregate and sectoral noise. We show that firms' overly pessimistic beliefs about

the aggregate effect of the carbon tax come from the public signal on the aggregate elasticity that is too pessimistic. This pessimistic public signal leads firms to be also excessively pessimistic about their own elasticity. We then use our data to identify the parameters that characterize firms' prior beliefs, which allows us to perform *information counterfactuals* that quantify how firms' intended responses would change if aggregate and sectoral noise were removed while keeping the underlying information structure otherwise unchanged. We find that removing noise in the aggregate public signal would reduce the expected fall in the firms' output by 30% on average. If we ignore the dampening effect of strategic substitutabilities, that number increases to 40%. Ultimately, the aggregate public signal, which we can interpret as the general public "sentiment" on the costs of decarbonizing, contributes in a non-negligible way to firms' pessimistic beliefs about the impact of carbon pricing.

Our paper contributes to a growing literature that uses survey data to recover firms' structural primitives that are otherwise difficult to identify from observational data. For instance, Keiller et al. (2024) demonstrate how carefully designed survey instruments can be used to estimate production-function parameters and adjustment frictions at the firm level. Coibion et al. (2021) show how firms' expectations can be exploited to study strategic interactions in price setting, highlighting the role of higher-order beliefs in firms' decisions. Closest to our approach, Afrouzi (2024) shows that survey scenarios can identify strategic complementarities in price setting by eliciting higher-order beliefs. We build on and extend this method by designing survey scenarios that vary the scope of a policy shock to jointly identify firm-specific cost elasticities and strategic interaction parameters.

Our methodology also provides results that relate to a large literature on strategic interactions in quantity setting. Standard models of Cournot competition imply strategic substitutability (Bulow et al., 1985; Vives, 1999), while macroeconomic models featuring aggregate demand externalities or network production can generate complementarities (Cooper and John, 1988; Benhabib and Farmer, 1994; Farmer, 1999). These complementarities typically amplify the impact of noisy information (Benhabib et al., 2015; Angeletos and La'O, 2013).[1] Existing work assumes the sign of strategic interactions. We provide direct survey-based firm-

[1]Strategic interaction parameters also shape the use of information, with complementarities leading to an under-use of private signals and substitutabilities leading to an under-use of public information (Morris and Shin, 2002; Angeletos and Pavan, 2007).

level evidence that quantity setting is characterized by strategic substitutability, especially at the sectoral and, to a lesser extent, at the aggregate level. We are the first to document this "zero-sum thinking" at the firm level. As a consequence, pessimistic beliefs about aggregate responses to carbon pricing dampen–rather than amplify–firms' own pessimistic responses. This mechanism highlights a previously undocumented channel through which information frictions interact with competitive forces to shape firms' expectations about policy reforms.

We also contribute to an emerging literature that shows that support for carbon pricing is shaped by (mis-)perceptions about its costs, distributional incidence, and macroeconomic effects, and that correcting these beliefs can substantially increase policy support (Carattini et al., 2018; Beiser-McGrath and Bernauer, 2019; Kallbekken and Sælen, 2011; Andre et al., 2024). While this work focuses primarily on households, much less is known about firms' beliefs about carbon pricing and how these beliefs interact with strategic considerations. Our paper contributes by measuring firm-level expectations about carbon pricing and showing how aggregate belief distortions shape firms' expected real responses.

Finally, our paper contributes to a growing literature that uses surveys of firm managers to study the economic and political economy implications of environmental policies. Martin et al. (2014) show that firms' perceived relocation risks under carbon regulation shape their responses and policy positions. Hensel et al. (2024) demonstrate that carbon pricing affects firms' and households' inflation expectations, pointing to a potentially important macroeconomic expectations channel. More broadly, OECD (2016) has emphasized the value of firm surveys as a tool to study environmental policies when administrative or balance-sheet data are unavailable or released with long lags. Our contribution is to use survey-based scenarios to go beyond eliciting firm managers' opinions and expectations about future environmental policies. Our approach allows us to estimate structural parameters that permit us to conduct counterfactual policy simulations about the effects of carbon pricing along multiple margins and at different levels of aggregation. This approach allows us not only to document firms' perceived costs of carbon pricing but also to quantify how aggregate beliefs and strategic interactions shape firms' intended responses, providing a bridge between micro-level survey evidence and general-equilibrium analyses of environmental policy.

2 The Model

We lay out a simple one-period model to illustrate the impact of carbon pricing on firms' decisions. We introduce carbon policies as a carbon tax. Firms know the tax, but they decide how much to produce before they know how the tax impacts their costs. Firms can reduce their carbon emissions through a carbon abatement technology or by reducing production (equivalently, labor). We show that the equilibrium decisions of the firms boil down to a game between firms with strategic interactions. We then pinpoint the parameters that we need to identify, and design an identification strategy based on a firm questionnaire.

2.1 Representative household

There is a representative household with utility

$$U = \frac{C^{1-\gamma}}{1-\gamma} - \phi^{-1}\frac{L^{1+\eta}}{1+\eta} \tag{1}$$

where C is a consumption bundle that depends on the consumption of imperfectly substitutable goods from different sectors: $C = \left(\sum_n C_n^{\frac{1-\epsilon^c}{\epsilon^c}}\right)^{\frac{\epsilon^c}{1-\epsilon^c}}$, where each sector-specific consumption C_n is itself a bundle of different consumption varieties C_{in} within the sector $C_n = \left(\sum_i C_{in}^{\frac{1-\rho^c}{\rho^c}}\right)^{\frac{\rho^c}{1-\rho^c}}$. L is a function of the labor supplied to the different sectors: $L = (\sum_n L_n^{1+\chi})^{\frac{1}{1+\chi}}$, where each sector-specific labor supply L_n is a function of the labor supplied to the firms producing individual varieties: $L_n = \left(\sum_i L_{in}^{1+\psi}\right)^{\frac{1}{1+\psi}}$. The budget constraint faced by the household is

$$\sum_n \sum_i P_{in} C_{in} = \sum_n \sum_i W_{in} L_{in} \tag{2}$$

where P_{in} is the price of variety i in sector n, W_{in} is the wage paid by the firm producing good i in sector n.

The household's optimal choices imply

$$\phi^{-1} C^{\gamma} L^{\eta} = \frac{W}{P} \tag{3}$$

$$C_n = C \left(\frac{P_n}{P} \right)^{-\epsilon^c} \tag{4}$$

$$C_{in} = C_n \left(\frac{P_{in}}{P_n} \right)^{-\rho^c} \tag{5}$$

$$L_n = L \left(\frac{W_n}{W} \right)^{1/\chi} \tag{6}$$

$$L_{in} = L_n \left(\frac{W_{in}}{W_n} \right)^{1/\psi} \tag{7}$$

$$\tag{8}$$

where P, P_n, W and W_n are price aggregators defined as $P = \left(\sum_n P_n^{1-\epsilon^c} \right)^{\frac{1}{1-\epsilon^c}}$, $P_n = \left(\sum_i P_{in}^{1-\rho^c} \right)^{\frac{1}{1-\rho^c}}$, $W = \left(\sum_n W_n^{1+1/\chi} \right)^{\frac{1}{1+1/\chi}}$, and $W_n = \left(\sum_i W_{in}^{1+1/\psi} \right)^{\frac{1}{1+1/\psi}}$.

2.2 Firms

Consider firm i in sector n. Its production function is

$$Q_{in} = [(1 + \beta_{in}) L_{in}]^{\frac{1}{1+\beta_{in}}} \tag{9}$$

where $\beta_{in} > 0$ is a firm-specific return-to-scale parameter.

We assume for simplicity that carbon emissions are proportional to output, so that

$$E_{in} = \phi_{in} Q_{in} \tag{10}$$

ϕ_{in} is the firm-specific carbon-intensity of production. One can think of this carbon-intensity as arising for instance from the firm-specific energy mix that combines dirty and green energy sources. This parameter is endogenous, as firms can lower their carbon intensity if they pay the abatement cost

$$\frac{\kappa_{in}}{2} \left(1 - \frac{\phi_{in}}{\bar{\phi}_{in}} \right)^2 Q_{in}.$$

$\bar{\phi}_{in}$ is the business-as-usual carbon intensity, that is, the carbon-intensity that would hold in the absence of abatement effort. κ_{in} is a parameter that reflects how costly it is for that firm to decarbonize its production. The abatement cost can

be thought of for instance as the cost of switching from a brown energy source to a green energy source, which requires some investment from the firm. The cost is quadratic in the carbon intensity and is proportional to total production. Firms are imperfectly informed about both $\bar{\phi}_{in}$ and κ_{in}, which means that they ignore both their business-as-usual carbon intensity and how much it would cost them to decrease it. The firm faces a tax tax_{in} per unit of carbon emission.

Timing and information At the beginning of the period, the firm decides how much labor to hire (equivalently, how much to produce). At that stage, the firm knows its own tax tax_{in} and the distribution of the tax within its own sector and in the firms' population, as well as the distribution of the preference and technolopgy parameters. However, the firm does not observe the business-as-usual carbon-intensity $\bar{\phi}_{in}$ and the cost parameter κ_{in}, nor their distribution within their sector or in the firms' population. Prices and abatement efforts are set at the end of period, after the firm learns about $\bar{\phi}_{in}$ and κ_{in} and their distribution.

Firm's decisions The firm behaves monopolistically within its sector. Its expected profits are

$$E_{in}\Pi_{in} = E_{in}\left\{P_{in}Q_{in} - W_{in}L_{in} - tax_{in}E_{in} - \frac{\kappa_{in}}{2}\left(1 - \frac{\phi_{in}}{\bar{\phi}_{in}}\right)^2 Q_{in}\right\} \tag{11}$$

For a given tax tax_{in}, the firm maximizes its profits (11) with respect to production Q_{in} and abatement effort ϕ_{in}, subject to the demand for its product (5), its production technology (9) and its emission technology (10).

According to our timing assumption, firms know the parameters of the abatement technology when they decide their abatement effort ϕ_{in}. As a result, the marginal abatement cost must be equal to the carbon tax:

$$tax_{in} = \frac{\kappa_{in}}{\bar{\phi}_{in}}\left(1 - \frac{\phi_{in}}{\bar{\phi}_{in}}\right) \tag{12}$$

When deciding their production Q_{in}, the firms do not know the parameters of the abatement technology yet. Taking into account the abatement efforts of the firm, the optimal level of production is then set so that the markup is constant in expectations:

$$E_{in}(P_{in}) = E_{in}\left\{\frac{\rho^c}{\rho^c - 1}\left(W_{in}Q_{in}^{\beta_{in}} + tax_{in}\bar{\phi}_{in}\left(1 - \frac{tax_{in}\bar{\phi}_{in}}{2\kappa_{in}}\right)\right)\right\} \tag{13}$$

2.3 Equilibrium

The consumption of variety i in sector n should be equal to the production of variety i in sector n:

$$C_{in} = Q_{in} \tag{14}$$

2.4 Strategic interactions in quantity setting

We have assumed that the firm has to make quantity decisions before the uncertainty on decarbonization parameters is resolved, while prices fully adjust after. This assumption will give us strategic interactions in quantity setting.

We log-linearize the model around the firm-specific baseline tax level $tax_{in} = \overline{tax}_{in}$, that we assume to be close to zero. We denote the log-deviations from the baseline by lower-case letters and denote by $\tau_{in} = tax_{in} - \overline{tax}_{in}$ the deviation of the tax from its baseline level, in euros say.

The firm must then set its production so that its markup does not deviate from its optimal level in expectations, and the price follows (13). The firm behavior can be approximated as follows:

$$E_{in}\left\{p_{in} - (w_{in} + \beta_{in} q_{in}) - \tilde{\sigma}_{in}\tau_{in}\right\} = 0 \tag{15}$$

where $\tilde{\sigma}_{in} = \frac{\bar{\phi}_{in}}{\bar{W}_{in}\bar{Q}_{in}^{\beta_{in}}}$ is the semi-elasticity of the marginal cost to τ_{in}, with $\bar{W}_{in}$, $\bar{Q}_{in}$ the baseline wage and output. Output increases the marginal cost through a decreasing-return-to-scale channel, which depends on the curvature of the production function parameter β_{in}. The carbon tax τ_{in} increases the marginal cost because it works as a tax on production.

Given our timing assumptions, the firm makes production decisions before observing market prices and before observing abatement cost parameters. But, to make a decision on output, the firm must infer the potential drivers of the inverse of the product wage $p_{in} - w_{in}$, and the price tax-elasticity $\tilde{\sigma}_{in}$, as implied by Equation (16):

$$q_{in} = \frac{1}{\beta_{in}}\left\{E_{in}(p_{in} - w_{in}) - E_{in}(\tilde{\sigma}_{in})\tau_{in}\right\} \tag{16}$$

The product wage can be decomposed as follows:

$$p_{in} - w_{in} = (p_{in} - p_n) + (p_n - p) - (w_{in} - w_n) - (w_n - w) - (w - p) \tag{17}$$

It depends on the variety's relative price, within its sector, and on the relative price of the sector within the aggregate economy. These will depend respectively on the supply of the variety relative to the sectoral supply, and on the supply of the sector relative to the aggregate supply. The product wage also depends on the wage, which has an individual, sectoral and aggregate component. These will depend respectively on the individual, sectoral and aggregate input demand.

We now derive the key equation that will guide our empirical investigation. Using the optimal output (16) and the product wage expression (17), and combining with the consumption demand and labor supply equations (3)-(7), the equilibrium relations (14), and the production function (9), we obtain the following log-linear approximation of the optimal individual output:

$$q_{in} = \alpha^a_{in} E_{in}(q) + \alpha^s_{in} E_{in}(q_n) - E_{in}(\sigma_{in})\tau_{in} + \omega \tag{18}$$

with $\sigma_{in} = \tilde{\sigma}_{in}/[\psi(1+\beta_{in}) + (\rho^c)^{-1} + \beta_{in}]$ and where α^s_{in} and α^a_{in} are the strategic complementarity parameters at the sectoral level $\alpha^s_{in} = \frac{(\psi-\chi)(1+\beta_n)+(\rho^c)^{-1}-(\epsilon^c)^{-1}}{(\psi(1+\beta_n)+\beta_{in})+(\rho^c)^{-1}}$ and at the aggregate level $\alpha^a_{in} = \frac{(\chi-\eta)(1+\beta)-\gamma+(\epsilon^c)^{-1}}{(\psi(1+\beta_{in})+\beta_{in})+(\rho^c)^{-1}}$, where β_n and β are respectively the sectoral and economy-wide averages of β_{in}. The constant term $\omega = [(\psi - \chi)Cov(\beta_{in} - \beta_n, q_{in} - q_n) + \chi Cov(\beta_n - \beta, q_n - q)]$ is negligible under some mild assumptions, as we will show later.

The crucial point about Equation 18 is that it summarizes the general equilibrium effects with two strategic interaction parameters: α^a describes strategic interactions between sectors, whereas α^s describes strategic interactions within a sector. These parameters are sufficient statistics that depend on the degree of competition in the product markets (governed by the elasticities of substitution ϵ^c and ρ^c) and in the input markets (governed by γ, η, ψ and χ). Moreover, the strength of the decreasing marginal returns (governed by β) also matters. Since the elasticity of substitution between sectors ϵ^c tends to be small ($\epsilon^c < 1$), α^a is typically positive, which means strategic complementarities between sectors are more likely. On the other hand, since the elasticity of substitution within sectors, i.e., across varieties, tends to be large ($\rho^c > 1$), α^s is typically negative, reflecting strategic substitutabilities between competing firms in the same sector.

2.5 Noisy beliefs and strategic interactions

We define "noisy beliefs" as a situation where firms have erroneous expectation about their own elasticities on average, that is, $\bar{E}(\sigma_{in}) \neq \sigma^a$, where $\bar{E}(\sigma_{in})$ is the economy-wide average of $E_{in}(\sigma_{in})$. As we will see, this implies that firms are also, on average, mistaken about aggregate and sectoral output: $\bar{E}(q) \neq q$ and $\bar{E}(q_n) \neq q$, that is, the average responses about the aggregate and sectoral expected output differs from the actual aggregate output, computed as the aggregate average of the firms' responses about their own production. We show that this has consequences on the expected impact of the carbon tax, and that these consequences are mitigated or amplified by strategic interactions.

We can show how strategic interactions and noisy beliefs interact by simply rewriting Equation (18) as

$$q_{in} = \alpha^a_{in}\left[q + (E_{in}(q) - q)\right] + \alpha^s_{in}\left[q_n + (E_{in}(q_n) - q_n)\right] - \left[\sigma_{in} + (E_{in}(\sigma_{in}) - \sigma_{in})\right]\tau_{in}. \tag{19}$$

This is the second equation that guides our empirical investigation. By quantifying noisy beliefs at the aggregate and sector level, we can show how they impact firm managers' beliefs about the impact of carbon pricing on their own output.

Moreover, we can also use Equation (19) to show how an aggregate error on the elasticity $\bar{E}(\sigma_{in}) - \sigma^a$, but also on aggregate production $\bar{E}(q) - q$, or on sectoral production $\bar{E}(q_n) - q$, affects the economy-wide response to a carbon tax. This can readily be seen by taking the economy-wide averages where we obtain:

$$q = \frac{1}{1 - \alpha^a - \alpha^s}\left[\alpha^a\left(\bar{E}(q) - q\right) + \alpha^s\left(\bar{E}(q_n) - q\right) - \left(\bar{E}(\sigma_{in}) - \sigma^a\right)\tau - \sigma^a\tau\right] \tag{20}$$

where τ is the average tax. Note that the impact of the different types of errors still depends on the strategic interaction parameters α^a and α^s.

Equation (20) can serve as a basis for information counterfactuals. If we were to change the nature of the signals impacting managers' beliefs, this would affect the different types of aggregate errors, and, in turn, the aggregate impact of a carbon tax. However, to determine how we can change managers' beliefs, we need to make further assumption on the information structure.

Information structure So far, our assumptions about the information structure were minimal. We simply assume that the carbon taxes τ_{in} and strategic interaction parameters α^a_{in} and α^s_{in} are known to all firms, but firms are uncertain

about the tax-related elasticities σ_{in}. To characterize the errors in Equation (20), we now formalize the information structure about σ_{in}, which allows us to show the role of public and private signals.

Let σ_{in}^f, σ_n^s and σ^a be some firm-level, sectoral and aggregate stochastic components of σ_{in}:

$$\sigma_{in} = \sigma^a + \sigma_n^s + \sigma_{in}^f$$

We assume that σ^a, σ_n^s and σ_{in}^f are Gaussian and mutually independent: $\sigma^a \sim \mathcal{N}(x^a, \pi_a^{-1})$, $\sigma_n^s \sim \mathcal{N}(0, \kappa_s^{-1})$, $\sigma_{in}^f \sim \mathcal{N}(0, \kappa_f^{-1})$, where the sectoral average of σ_{in}^f and the economy-wide average of σ_n^s are equal to zero. $x^a = E^a(\sigma^a)$ is the common prior about the economy-wide component σ^a, and π_a is the precision of this prior. This constitutes the public information about σ^a.

This aggregate prior can be decomposed into the actual fundamental and some "surprise", or noise:

$$x^a = \sigma^a + e^a$$

where e^a follows the distribution $e^a \sim N(0, (\pi^a)^{-1})$.

We additionally assume that, before making a production decision, firm i observes a sector-level signal on the sectoral elasticity σ_n,

$$y_n^s = \sigma_n + e_n^s = \sigma^a + \sigma_n^s + e_n^s$$

with $e_n^s \sim N(0, (\pi^s)^{-1})$ averaging out to zero at the aggregate level, and an individual signal on the firm-level elasticity σ_{in},

$$z_{in}^f = \sigma_{in} + e_{in}^f = \sigma^a + \sigma_n^s + \sigma_{in}^f + e_{in}^f$$

with $e_{in}^f \sim N(0, (\pi^f)^{-1})$ averaging out to zero at the sectoral and aggregate level. It is natural to assume that firms within a sector observe the same information about the sectoral elasticity. It is also natural to assume that they observe their own elasticity σ_{in} imperfectly, but that there is no systematic aggregate or sectoral noise in that signal. Conditional on this private signal, some firms may overestimate or underestimate their elasticity, but on average they observe it correctly.

While the prior x^a is common knowledge, y_n^s and z_{in}^f are private signals. z_{in}^f is only observed by the firm, and y_n^s is only observed by firms within sector n.

Building on the assumptions on the information structure, and some additional assumptions, the model solution is characterized in Appendix A: we show that, for a given tax schedule $(\tau, \tau_n, \tau_{in})$, where τ is the average tax across all firms and τ_n

is the average tax within the sector, the solutions for the firm's own output, and the firm's expectations about the aggregate and sectoral outputs, are linear in the signals. We then derive the following proposition, which shows that noisy beliefs appear (see proof in Appendix C.3):

Proposition 1 (Noisy beliefs)**.** *The average error on the firms' own elasticity, and on the aggregate and sectoral output responses to an economy-wide tax τ, are proportional to e^a, the noise in the public signal:*

$$\bar{E}(\sigma_{in}) - \sigma^a = \delta^x e^a \tag{21}$$

$$\bar{E}(q) - q = -(\gamma^y + \gamma^z)\delta^x_a e^a \tau \tag{22}$$

$$\bar{E}(q_n) - q = -\gamma^z \tilde{\delta}^x e^a \tau \tag{23}$$

where δ^x, δ^x_a and $\tilde{\delta}^x$ are the weights put by the firm on the public prior x^a when forecasting, respectively, its own elasticity, the aggregate elasticity, and the sectoral elasticity, while (γ^y, γ^z) are the responses of individual output to the private signals (y^s_n, z^f_{in}) for each unit of aggregate tax τ.

We have $0 \leq \delta^x \leq 1$, $0 \leq \delta^x_a \leq 1$ and $0 \leq \tilde{\delta}^x \leq 1$. Additionally, if $|\alpha^a|^{\frac{1}{2}} + |\alpha^s|^{\frac{1}{2}} < 1$, we have $\gamma^y + \gamma^z \geq 0$ and $\gamma^z \geq 0$.

If either z^f_{in} or y^s_n are perfect signals ($\pi^f = +\infty$ or $\pi^s = +\infty$), then $\delta^x = 0$ and there is no aggregate error on σ_{in}. If, on the opposite, neither z^f_{in} nor y^s_n is informative ($\pi^f = \pi^s = 0$), then $\gamma^y + \gamma^z = 0$ and there is no aggregate error on q. If z^f_{in} is not informative ($\pi^f = 0$), then $\gamma^z = 0$ and there is no aggregate error on q_n.

Noisy beliefs appear when there is aggregate noise: $e^a \neq 0$. Firms combine the public prior x^a with the private signals y^s_n and z^f_{in} to infer their elasticity. As a result, the noise in the public signal e^a drives the average error. When the prior about the aggregate elasticity is too high ($e^a > 0$), firms over-estimate their own elasticity on average. This is true as long as the private signals are not perfect, otherwise, the firms would not rely on public information.

Aggregate noise also leads firms to make an error on quantities, on average. This is due to the presence of private information. Since individual quantities respond to the firms' private signals, the aggregate and sectoral quantities will reflect information that is not common knowledge. As a result, to form expectations on q and q_n, firms must infer the aggregate and sectoral elasticities, based on

their imperfect information, and they make use of the public signal x^a, which will generate some average error driven by e^a.[2]

The aggregate errors on quantities thus inform us on the aggregate error firms make on their own elasticity. Conditional on the assumption that strategic interaction parameters are not unrealistically large ($|\alpha^a|^{\frac{1}{2}} + |\alpha^s|^{\frac{1}{2}} < 1$), the errors on quantities and the error on the firms' own elasticity are of opposite signs. If firms underestimate aggregate output ($\bar{E}(q) - q < 0$), it indicates that they get an overly pessimistic public signal on the aggregate elasticity ($e^a > 0$), which implies that they will also be over-pessimistic about their own elasticity on average ($\bar{E}(\sigma_{in}) - \sigma^a > 0$). This can be inferred by asking firms about their beliefs about their own response q_{in} to a carbon tax τ, and their higher-order beliefs $E_{in}(q)$. Aggregating their individual responses in order to estimate q, we can test whether $E_{in}(q) - q \neq 0$. If that error is negative (positive), it would indicate that the public signal x^a is excessively pessimistic ($e^a > 0$).

Combined with Equation (20), these results imply that noise in the public signal e^a has aggregate consequences. First, a positive average error on σ_{in}, driven by a positive e^a, leads firms to respond excessively negatively to a tax τ. Moreover, it would imply that the errors on q and q_n would be negative on average. The way these errors contribute to aggregate output depends on the strategic parameters α^a and α^s. In the presence of strategic complementarities (if these parameters are positive), then the effect of the noise e^a on output is amplified. In the presence of strategic substitutabilities (if these parameters are negative), then the effect of the noise e^a on output is dampened, or even reversed.

The purpose of the following section is to identify the strategic interaction parameters (α^a, α^s), the beliefs about the elasticity $E_{in}(\sigma_{in})$, as well as the first- and higher-order beliefs $(q_{in}, E_{in}(q), E_{in}(q_n))$ in order to inform our understanding of these mechanisms.

[2]For firms to be unable to perfectly forecast aggregate output, some private information is required either at the firm or sector level, through either y_n^s or z_{in}^f. However, the sectoral signal y_n^s is common knowledge within a sector. Therefore, for firms to be unable to perfectly forecast sectoral output, some private information at the firm level is necessary, through z_{in}^f.

3 Identification Strategy

Here we discuss how to identify the firms' beliefs about the elasticities $E_{in}(\sigma_{in})$ and the degree of strategic complementarities α^a_{in} and α^s_{in}. In process, we collect firms' responses q_{in} to a carbon tax increases, and their higher-order beliefs $(E_{in}(q), E_{in}(q_n))$, which we can use to evaluate noisy beliefs.

3.1 Strategic interactions and firm-level elasticities

Suppose that we want to identify the firms' beliefs about the elasticities $E_{in}(\sigma_{in})$ and the degree of strategic complementarities α^a_{in} and α^s_{in}, or in other words, the vector $(\alpha^a_{in}, \alpha^s_{in}, E_{in}(\sigma_{in}))'$. Equation (18) suggests that this is possible if we generate variations in policies, firm-level quantities, and firm-level expectations about aggregate and sectoral quantities, namely in the vector $(q_{in}, E_{in}(q), E_{in}(q_n), \tau_{in})'$. On the other hand, Proposition 3 in Appendix A, suggests that, conditional on the parameters and signals (Θ_{in} and S_{in}), variations in $(q_{in}, E_{in}(q), E_{in}(q_n))'$ are driven by variations in $(\tau, \tau_n - \tau, \tau_{in} - \tau_n)'$. We thus can produce observations of $(q_{in}, E_{in}(q), E_{in}(q_n), \tau_{in})'$ through survey questions where firms are provided with different scenarios on $(\tau, \tau_n - \tau, \tau_{in} - \tau_n)'$.

Because there are three parameters to identify, it is enough to generate three independent observations of the vector $(q_{in}, E_{in}(q), E_{in}(q_n), \tau_{in})'$. In that case, we can write

$$\begin{pmatrix} q_{in,1} \\ q_{in,2} \\ q_{in,3} \end{pmatrix} = \underbrace{\begin{pmatrix} E_{in}(q_1) & E_{in}(q_{n,1}) & \tau_{in,1} \\ E_{in}(q_2) & E_{in}(q_{n,2}) & \tau_{in,2} \\ E_{in}(q_3) & E_{in}(q_{n,3}) & \tau_{in,3} \end{pmatrix}}_{P_{in}} \cdot \begin{pmatrix} \alpha^a_{in} \\ \alpha^s_{in} \\ E_{in}(\sigma_{in}) \end{pmatrix}$$

where the 1, 2 and 3 subscripts correspond to three distinct scenarios. Provided that P_{in} is invertible, we can recover $(\alpha^a_{in}, \alpha^s_{in}, E_{in}(\sigma_{in}))'$ as follows:

$$\begin{pmatrix} \alpha^a_{in} \\ \alpha^s_{in} \\ E_{in}(\sigma_{in}) \end{pmatrix} = P_{in}^{-1} \begin{pmatrix} q_{in,1} \\ q_{in,2} \\ q_{in,3} \end{pmatrix}$$

Therefore, the parameters are identified if and only if P_{in} is invertible.

We can ensure that P_{in} is invertible by presenting firms with the following three scenarios, that vary in *scope*: (1) an increase ϵ in the economy-wide tax: $\tau = \epsilon$ and $\tau_n - \tau = \tau_{in} - \tau_n = 0$; (2) an increase ϵ in the tax in the sector where the firm

operates (but not in the rest of the economy): $\tau_n - \tau = \epsilon$ and $\tau = \tau_{in} - \tau_n = 0$; (3) an increase ϵ in the tax that applies to the firm (but not to the rest of the economy, including the sector where the firm operates): $\tau_{in} - \tau_n = \epsilon$ and $\tau = \tau_n - \tau = 0$. In each of these scenarios, we ask firms about their own production, the production in their sector, and aggregate production.

With these scenarios, we ensure that P_{in} is upper-triangular, with non-zero diagonal elements:

$$P_{in} = \begin{pmatrix} E_{in}(q_1) & E_{in}(q_{n,1}) & \epsilon \\ 0 & E_{in}(q_{n,2}) & \epsilon \\ 0 & 0 & \epsilon \end{pmatrix} \tag{24}$$

which ensures invertibility (see Appendix B for a full derivation).

Discussion What is key here? We need (i) three independent scenarios on the different tax levels (individual, sectoral and aggregate), and (ii) that these different tax levels drive independent responses of the three right-hand-side variables in Equation (18). Regarding (i), the fact that we consider firm-level, sector-level and aggregate scenarios of the tax provides naturally independent scenarios. Regarding (ii), the three variables in P_{in} that we consider (expected aggregate production, expected sectoral production, and the tax) are independent because the three variables are affected differently by the three scenarios. Naturally, aggregate, sectoral and firm-level variables are affected differently by aggregate, sectoral and firm-level taxes. In particular, a natural implication of our model is that aggregate output does not react to the sectoral and individual scenarios, and that sectoral output does not react to the individual scenario, hence the lower-triangular shape of P_{in}.

This identification strategy is different from the one implemented by Afrouzi (2024), who uses survey questions to identify the degree of strategic complementarity in price setting. Transposing to our firms' quantity decisions, it would amount to identify the parameters of a version of Equation (18) that abstract from the sectoral level, using the following question: "Suppose that you get news that the general level of the carbon policy went up by ϵ in the economy:

(a) By what percentage do you think aggregate production would change?

(b) By what percentage would your firm change its production level?

(c) By what percentage would your firm change its production level if aggregate production did not change at all in response to this news?"

This generates variations in $(q_{in}, E_{in}(q), \tau_{in})$ that help identify the parameters $\bar{\alpha}^a_{in}$ and $E_{in}(\sigma_{in})$:

$$\begin{pmatrix} \bar{\alpha}^a_{in} \\ E_{in}(\sigma_{in}) \end{pmatrix} = \begin{pmatrix} E_{in}(q_1) & \epsilon \\ 0 & \epsilon \end{pmatrix}^{-1} \begin{pmatrix} q_{in,1} \\ q_{in,2} \end{pmatrix}$$

where $E_{in}(q_1)$ is the answer to (a), $q_{in,1}$ is the answer to (b) and $q_{in,2}$ is the answer to (c).

Contrary to us, Afrouzi would consider only one policy scenario and would generate variations by artificially shutting down some channels, here $E_{in}(q_2) = 0$. His approach is close to ours, but the advantage of our approach is that it is more natural and allows a better control of the environment. For instance, it is not clear what firms infer from the assumption $E_{in}(q_2) = 0$.

3.2 Aggregate errors and noisy beliefs

Scenarios 1 and 2 provide us with a set of individual responses and higher-order beliefs. In Scenario 1, we collect $(q_{in,1}, E_{in}(q_n, 1), E_{in}(q_1))$, for an aggregate tax $\tau = \epsilon$. In Scenario 2, we collect $(q_{in,2}, E_{in}(q_n, 2))$, for a sector-specific tax $\tau_n - \tau = \epsilon$.

We can compute $\bar{E}(q_1) - q_1$ and $\bar{E}(q_{n,1}) - q_1$, where q_1 is the aggregate response implied from the individual responses, and $\bar{E}(q_1)$ and $\bar{E}(q_{n,1})$ are an average of the responses on the firms' higher-order beliefs. These, in theory, satisfy respectively (22) and (23) with $\tau = \epsilon$, which yields

$$\bar{E}(q_1) - q_1 = -(\gamma^y + \gamma^z)\delta^x_a e^a \epsilon \tag{25}$$

$$\bar{E}(q_{n,1}) - q_1 = -\gamma^f \tilde{\delta}^x e^a \epsilon \tag{26}$$

We can also compute $\bar{E}_n(q_{n,2}) - q_{n,2}$, with $\bar{E}_n(q_{n,2})$ the sectoral average of $E_{in}(q_{n,2}))$. This sectoral error is in theory also proportional to e^a on average:

$$\bar{E}(q_{n,2}) - q_2 = -\tilde{\gamma}^z \tilde{\delta}^x e^a \epsilon \tag{27}$$

with $\tilde{\gamma}^z \geq 0$. See proof in Appendix C.4. These three aggregate errors can thus be used to infer the sign of the noise e^a.

4 The Survey

We surveyed managers from a representative sample of Swiss firms. This section describes the survey design, sample construction, manager recruitment, and

implementation.

4.1 Survey Design

The survey was administered online between June and August 2025 and organized into several modules. The English version of the questionnaire is provided in Appendix E.

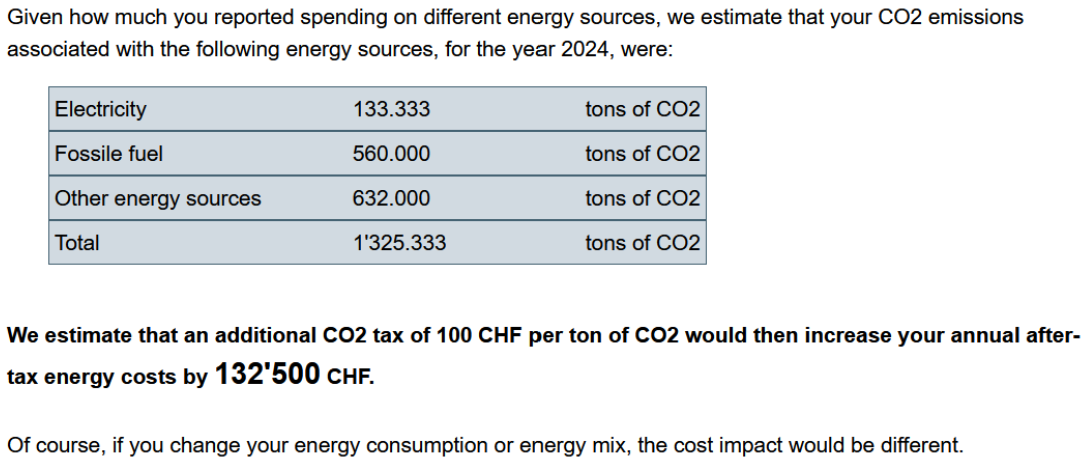
Introduction. Respondents first selected their preferred language (German, French, or English) and were then presented with a consent form in neutral language that briefly described the purpose of the survey.

Firm characteristics. The next module elicited firm characteristics used in the heterogeneity analysis. We collected information on firms' sector of activity, geographic location, number of employees, turnover, and export share in the previous year. Respondents also reported perceived competition intensity in their sector (7-point ordinal scale), the geographic location of their main competitors (five categories ranging from *all in Switzerland* to *all abroad*), total operating expenses, the share of expenses devoted to energy, and the composition of energy inputs (electricity, fossil fuels, and other sources such as waste, coal, or wood).

Carbon tax cost estimate. We designed a procedure to help managers assess the potential cost of a carbon tax increase by providing firm-level estimates of CO_2 emissions and the associated tax liability. Combining the previously collected data on energy operating costs and energy source shares with Swiss energy prices and energy source-specific CO_2 coefficients, we estimated each firm's total CO_2 emissions from direct fossil fuel consumption. This information was then used to inform managers how a carbon tax increase of CHF 100 (treatment group 1) or CHF 300 (treatment group 2) per ton of CO_2 translates into an additional annual cost (see Figure 1), where managers were assigned randomly to one of the two treatment groups.[3] Appendix Table **??** provides an example of how the cost increase was estimated, together with the CO_2 coefficients used. Formally, one

[3]The Swiss carbon tax on fossil thermal fuels is currently 120 CHF per ton of CO_2. Our CHF 300 tax increase treatment aligns with Ecoplan and INFRAS (2024) who recommend, in a report for the Swiss government, a tax of 430 CHF to internalize the social cost of carbon.

can think of this procedure as providing a private, firm-specific signal about the cost elasticity σ_{in} that we aim to estimate. The signal is noisy but contains no systematic aggregate or sectoral bias, preserving the information structure required for identification.



Given how much you reported spending on different energy sources, we estimate that your CO2 emissions associated with the following energy sources, for the year 2024, were:

Electricity	133.333	tons of CO2
Fossile fuel	560.000	tons of CO2
Other energy sources	632.000	tons of CO2
Total	1'325.333	tons of CO2

We estimate that an additional CO2 tax of 100 CHF per ton of CO2 would then increase your annual after-tax energy costs by 132'500 CHF.

Of course, if you change your energy consumption or energy mix, the cost impact would be different.

Figure 1: Carbon Tax Cost Estimate

Notes: The values shown are illustrative and correspond to reported operating expenditures of CHF 10,000,000, an energy expenditure share of 10%, and energy source shares of 40% electricity, 40% fossil fuels, and 20% other sources.

Carbon tax scenarios—production effects. The next module forms the core of the survey for our empirical strategy. Each manager was presented with three scenarios, which vary the coverage scope of the carbon tax increase but are identical in terms of the amount of the tax increase and all other provided information:

- Scenario 1 (national tax τ): The tax increase is applied to all firms in Switzerland.
- Scenario 2 (sectoral tax τ_n): The tax increase is applied only to firms in the same sector as the respondent's firm.
- Scenario 3 (firm-specific tax τ_{in}): The tax increase is applied only to the respondent's own firm.

Importantly, these scenarios map exactly into the three scenarios required for our identification strategy (Section 3). For each scenario, managers were asked to

assess the expected percentage change in annual production volume of goods and services (measured at current sales prices) three years (i.e., in the medium-run) after the implementation of the tax increase, relative to the situation with no additional tax increase. Specifically, each firm manager i of sector n estimated:

- The impact of Scenario 1 on Switzerland's total production, $E_{in}(q_1)$
- The impact of Scenarios 1 and 2 on competitors' production, $E_{in}(q_{n,1})$ and $E_{in}(q_{n,2})$
- The impact of Scenarios 1, 2, and 3 on their own firm's production, $q_{in,1}$, $q_{in,2}$, and $q_{in,3}$.

Assuming that firms are small relative to the rest of their sector, and that the aggregate effect of the sectoral tax scenario is negligible, we obtain for each firm manager the following system of equations:

$$\begin{pmatrix} q_{in,1} \\ q_{in,2} \\ q_{in,3} \end{pmatrix} = \begin{pmatrix} E_{in}(q_1) & E_{in}(q_{n,1}) & \tau \\ 0 & E_{in}(q_{n,2}) & \tau_n \\ 0 & 0 & \tau_{in} \end{pmatrix} \cdot \begin{pmatrix} \alpha^a_{in} \\ \alpha^s_{in} \\ E_{in}(\sigma_{in}) \end{pmatrix}, \tag{28}$$

which allows recovery of the firm-specific parameter vector $\{\alpha^a_{in}, \alpha^s_{in}, E_{in}(\sigma_{in})\}$.

Carbon tax scenarios—effects on prices, labor, energy use, and profits. Although our analysis focuses on production outcomes, we also elicited managers' expectations about the effects of the scenarios on final prices at the economy-wide, sectoral, and firm level.[4] For the national tax scenario, we further elicited expected effects on own firms' energy consumption, number of employees, and profits.

Carbon tax support. After the scenario modules, we asked managers about their preferences regarding the carbon tax level. They were first reminded that the current Swiss carbon tax sets a CO2 price of CHF 120 per ton and applies to approximately 75 percent of Switzerland's CO2 emissions. Managers were then asked, from the perspective of their firm, to indicate the ideal CO2 price under two scenarios: (1) No exemptions: the current tax is replaced by a new regime

[4]Our model relies on assumptions about the information structure, in particular the timing of information shocks (Section 2.2), which are tailored to production decisions. Equation (18) applies to prices only if the information-timing assumptions hold also for pricing behavior.

covering all sectors and CO2 emissions in Switzerland. (2) Selective exemption: only the respondent's own firm and its competitors are exempt from the new tax regime.

Carbon intensity and participation in carbon policies. Next, managers were asked to assess their firm's CO_2 intensity relative to their sector, and their sector's intensity relative to the economy as a whole, using an ordinal scale with categories *lower*, *equal*, and *higher*. In addition, managers reported whether their firm is exempt from the Swiss carbon tax, participates in the Swiss Emission Trading System, and participates in the federal program for voluntary CO_2 reductions.

Manager characteristics and concluding questions. To conclude the survey, respondents reported their tenure at the firm, current position, age, gender, and education level. In the final module, managers indicated whether they wished to participate in future surveys and whether they wanted to receive a report summarizing the survey results; those who agreed provided their name and email. In addition, managers rated the questions for interest and difficulty, using four-category ordinal scales.

4.2 Data Collection

Contact sample. We drew the firm contact sample from three sources: the Orbis company database (Moody's Analytics, 2025), the firm panel of the KOF Institute (KOF Institute, 2025), and an address panel from a 2023 survey (Benhima et al., 2024). The sample includes approximately 27,000 firm contacts and is representative of the firm population in the Swiss Business and Enterprise Register (BER) at the sector–size stratum level, with two coverage exclusions: sectors outside the market economy and firms located in the Italian- and Romansh-speaking regions, which account for 6 percent of the BER. Rather than applying purely proportional stratified sampling, we oversampled larger firms and sectors expected to exhibit above-average responses to carbon tax increases or higher within-stratum heterogeneity, to ensure sufficient precision in strata that contribute disproportionately to aggregate outcomes. In the analysis, we correct for oversampling by reweighting firms to match population statistics. Appendix G provides additional details on the construction of the contact sample and the oversampling procedure.

Survey implementation. We invited firm contacts via e-mail to participate in the survey on June 17, 2025, in German, French, or English, depending on the firm's language region or previously indicated preference. For firms in the KOF and 2023 panels, messages included personalized salutations addressed to the identified contact person, whereas for firms in the Orbis panel—where e-mail addresses typically correspond to general company inboxes—a generic salutation was used. The invitation, written in a neutral tone, provided a brief explanation of the survey's purpose, a secure direct link to the online survey, and, as an alternative, access via a login page using a password included in the invitation; it also offered exclusive access to a summary report of the results. Invitations were signed by the authors of this study and included links to their university websites. Two reminders were sent, and the survey was closed on August 31, 2025.

Response statistics. From the 27k firms we contacted, 4116 managers opened the survey link, 2356 started but did not complete the survey, and 1408 proceeded until the end of the survey. Among those who completed the survey, 1145 answered the scenario questions on the impact of a carbon tax on production. These managers are our estimating sample. Note that some managers (N=95) completed only some of the questions for the different scenarios but still proceeded until the end of the survey. Among the managers who did not complete the survey (N=2708), 20% dropped after answering only a few questions related to their main sector of activity or number of employees, and another 20% dropped during the carbon tax scenario questions.

For our main analysis, we focus on managers who completed the survey and provided complete answers to the scenario questions regarding production impacts. Table 1 describes the main sample along different characteristics.[5] The typical firm in our sample has a median of 18 full-time employees and CHF 4 million in turnover, though the distribution is highly right-skewed (mean of 93 FTE and CHF 131 million). Firms report modest energy cost shares (median 2% of total costs). CO_2 emissions are nonetheless important (median 43 tons). Interestingly, a large majority perceive their own emissions as lower than those of other firms in their

[5] In Appendix D, we also compare the samples of managers who started but did not complete the survey with the main sample. One notable difference is with respect to firm size. Managers who completed the survey belong to firms that were systematically smaller than the firms of managers who only started the survey.

sector (96%) and their sector's emissions as lower than those of other sectors (87%). Respondents are predominantly male (86%), senior decision-makers (76% CEO or CFO), with a median age of 52 and an average of 17 years at their company; when asked about their ideal carbon price, the median response is CHF 100 per ton of CO_2, rising slightly to CHF 110 if they were to be exempted.

5 Descriptive Evidence

We first report the mean outcomes for all the different impacts we elicited for a national carbon tax reform (In Table 2). We distinguish the means across tax levels each manager was assigned to (100 CHF/tCO_2 or 300 CHF/tCO_2). Note that this variation is not required for our main identification of strategic interaction parameters or prior beliefs. We use this between-subject variation to show that managers are sensitive to the level of the carbon tax, on average.

The first row of Table 2 corresponds to the increase in energy costs resulting from the carbon tax. The 100 CHF/tCO_2 tax translates into a 8.11% increase in energy cost on average, and the 300 CHF/tCO_2 tax has an impact that is three times larger, as expected. These are the estimates we computed using the cost and energy share information collected from managers. Managers expect a reduction in their firm's output of about -1.47% for the lower tax, and a decrease of -2.42% for the higher tax—a difference that is statistically significant (p-value=0.01). Managers also expect to pass these costs to consumers. They report that they will increase the price of their main final product by 2.70% to 2.99%, for the low and high tax levels, respectively. For the other outcomes, i.e., energy consumption, employment (measured with full-time employee), and profits, we also observed the expected sign. On average, managers report that they will lower their energy consumption by -1.26% or -1.40% depending on the tax level. The impacts on labor and profits are negative. For profits, they are larger and statistically different at the higher tax level compared to the lower tax level.

It is difficult to directly compare our results with observational studies that report elasticities with respect to energy prices. These studies typically focus on a specific sector, notably the industrial sector, and use natural experiments, such as short-term price shocks arising from energy crises, that may not readily be comparable to an anticipated carbon pricing reform. Nonetheless, in Panel

B of Table 2, we compute the implied elasticities for the different outcomes we measure so it can be compared. Overall, our results are in line with the range of elasticities found in observational studies. For instance, several studies focusing on the industrial sector find that the short-run price elasticities of energy demand are typically small, even in response to large price shocks (Alpino et al., 2024). A meta-analysis by Labandeira et al. (2017), which primarily focuses on residential energy demand, reports average short-run price elasticities of -0.168 and -0.224 for the industrial and commercial sectors, respectively, which are consistent with the magnitudes of our elasticities.

With respect to other outcomes, some observational studies also report output and employment elasticities with respect to energy prices. Marin and Vona (2021), for instance, found output elasticities with respect to energy prices that range from -0.2 to -0.3, and about -0.25 for employment, which is very close the our output and employment elasticities.

Studies examining the impact of the EU-ETS are also relevant. One important caveat is that these studies mostly focus on the manufacturing sector and on the initial phases of the policy when permit prices were low. These ex post analyses typically find no to minimal impacts on employment and output (Martin et al., 2014; Dechezleprêtre et al., 2023; Colmer et al., 2025). Our estimates, on the other hand, suggest managers expect a negative impact for a substantially higher carbon price.

Finally, note that our elasticities do not scale linearly with the tax level. We observe something akin of scope insensitivity at the higher tax level. The highest tax level we present corresponds to a carbon price that firm managers in Switzerland, or anywhere else, have never experienced. It is thus possible that managers may not foresee the full extent of such a large change. At the same time, it is possible that we pick-up a non-linear response to a large tax change.

Next, we investigate how managers responded to the scope of the carbon tax reform across the three scenarios we presented to each of them. As shown in Table 3 (Panel A), managers report larger, i.e., more negative, impacts from a carbon pricing scheme that targets only their firm, versus their sector, or the whole economy. For a national scheme, managers expect a reduction in output of -1.14%, on average, which decreases to -1.53% for a sectoral scheme, and to -2.37% for firm-specific tax. Note that for all those estimates, we have normalized

the impact for a 100 CHF/tCO$_2$ tax.[6]

Finally, we also investigate variation in managers' beliefs about the impact of carbon tax reform on their own output versus other firms' output. Remember that, for a national carbon tax, we elicit, in addition to the change in their own production, what they believe the change in production across the whole economy and in their sector will be. In Table 3 (Panel B), we show that managers more pessimistic higher-order beliefs, on average, especially about the aggregate impacts. The average firm's reduction in output is less pronounced than the (average) expected impact on the whole economy. Managers thus systematically believe that the economy, and to a lesser extent their sector, would be hit harder than what they collectively report about the impact on their own firm.

Table 3 also reports the share of managers that expect a negative, nil, or positive production impact for a given carbon tax scenario. Whereas nearly 50% of managers expect a negative impact on their own or others' production, a significant share expect no impact. Finally, a small share, ranging from 13% to 16% across scenarios and outcomes, expects a positive impact.

6 Strategic Interaction and Noisy Beliefs

We now turn to the estimation of the strategic interaction parameters and noisy beliefs. For the estimation, we focus on a sample of managers who completed the survey and provided answers to all scenario questions pertaining to the output response to the different carbon tax reforms.

6.1 Strategic Interaction Parameters

We use the system of equations (28) to recover the vector of parameters $\{\alpha^a_{in}, \alpha^s_{in}, E_{in}(\sigma_{in})\}$, one for each manager who responded to the survey. Figure 2 presents the distribution of the three parameters. We observe a mode at zero, especially for the two strategic interaction parameters, and their means are both negative, as shown in Table 4. Output responses are thus strategic substitutes, on average. These averages, however, mask important variations across the distribution. To see this,

[6] To do so, we have divided the expected impacts of managers that received the 300 CHF/tCO$_2$ tax by three.

consider Figure 3, which is a binned scatter plot showing the joint distribution of α^a_{in} and α^s_{in}. There are two important takeaways.

First, the distribution of the sectoral strategic parameter spans mostly negative values, unlike the distribution of the aggregate strategic parameters, which has support that ranges from negative to positive values. Strategic interactions at the sectoral level are thus clearly strategic substitutes. At the aggregate level, it is ambiguous. For some managers, aggregate output is a strategic complement; for others, it is a strategic substitute.

Second, the correlation between the two parameters shows that the intensity of strategic interactions is strongly correlated across both dimensions. Large negative or positive values of α^a_{in} arise at the tail of the distribution of α^s_{in}. This means that managers who are strategic about how they believe other firms in their sector would respond are also strategic about the change in aggregate output.

We further document heterogeneity patterns by correlating the parameters with observables. Figure 4 shows binned scatter plots that represent the correlation between the strategic parameters and the intensity of competition and energy intensity. The sectoral strategic interaction parameter shows a strong correlation with both variables. Managers who perceive more intense competition from other firms in their sector and are more energy-intensive are more likely to respond strategically by considering other firms' output responses. But only for firms in their sector. At the aggregate level, the correlations are weaker.

We formally test these correlations using regressions of the strategic parameters on a large set of observables collected in the survey. Results are presented in Table 5. In Column I, the dependent variable is the parameter α^s_{in}, whereas in Column II, the dependent variable is a dummy variable that takes a value of 1 if the parameter α^s_{in} is non-zero. Similarly, columns III and IV are for the dependent variable α^a_{in} and a dummy variable indicating whether α^a_{in} is nonzero. We find that among all observables, competition-related variables, such as the self-reported intensity of competition variable, export shares, and whether competitors are only Swiss, are strongly correlated with both strategic parameters. Higher exposure to a carbon tax, which is captured by a high share of energy cost in total costs, and the use of fossil fuels are also correlated.

6.2 Noisy Beliefs

How accurate are managers' beliefs about the impacts of carbon pricing on other firms? To answer this question, we compute aggregate errors (national or sectoral). First, we construct the relevant realized aggregate output change by summing all the managers' estimates of own output change. We then define the manager's error as the difference between the manager's expectations for the impact on others and the realized aggregate impact. For instance, in the scenario for the national carbon tax, the realized aggregate output change is

$$q \;=\; \sum_i q_{in},$$

so the corresponding error is made by manager i is:

$$\varepsilon_{in} \;=\; E_{in}(q) - q.$$

Similarly, for the scenario with a carbon tax in sector n, the realized sectoral output change is

$$q_{n,s} \;=\; \sum_{i \in n} q_{in,s},$$

and the sectoral error is defined as

$$\varepsilon^s_{in}(n) \;=\; E_{in}(q_{n,s}) - q_{n,s}.$$

Finally, aggregate errors are assessed by averaging these errors across observations and evaluating whether the mean error differs from zero. In calculating q and $q_{n,s}$, one important question is whether we have a representative sample such that these quantities truly represent the whole economy and its sector, respectively. Re-weigthing could change the value of these aggregate quantities and impact the aggregate errors we report.

In Table 4, we report results using inverse probability weighting to obtain a representative sample by firm size. In the appendix, we provide more details on our approach and also provide additional results based on alternative weighting methodologies. Our main results are qualitatively the same. Managers tend to have noisy beliefs as they overestimate the impact on others compared to the true aggregate impacts. This is particularly evident for the national impact of a carbon tax. Managers are overly pessimistic about the aggregate impact compared to what they believe about their own impact. In simple terms, every manager believes that their firm will be less affected, on average, than the rest of the economy.

7 Counterfactual Analysis

The purpose of the following section is to estimate the impact of the estimated errors on aggregate output. More specifically, the experiment we would like to conduct is to remove the sectoral and aggregate noise:

Definition 1 (Removing noise)**.** *Removing noise consists in changing the information set of the firms so that there is no aggregate noise, that is, replacing* $S_{in} = (x^a, y_n^s, z_{in}^f)'$ *with* $\tilde{S}_{in} = (\sigma^a, y_n^s, z_{in}^f)'$*, but without changing the information structure.*

In this experiment, we assume that the aggregate signal is without noise, but firms still consider this signal as potentially biased. This is equivalent to setting $e^a = 0$.

As a result of removing noise, the aggregate errors vanish, and aggregate output only reflects the aggregate elasticity, as stated in the following proposition:

Proposition 2 (Counterfactual output)**.** *When removing noise as described in Definition 1, the errors vanish:* $\bar{E}(q) - q = \bar{E}(q_n) - q = \bar{E}(\sigma_{in}) - \sigma^a = 0$*, and aggregate output is*

$$q^{noiseless} = \frac{-\sigma^a \tau}{1 - \alpha^a - \alpha^s} \tag{29}$$

The wedge between the noisy and noiseless output depends only on the aggregate errors:

$$q^{noisy} - q^{noiseless} = \frac{1}{1 - \alpha^a - \alpha^s} \left(\alpha^a \left(\bar{E}(q) - q \right) + \alpha^s \left(\bar{E}(q_n) - q \right) - \left(\bar{E}(\sigma_{in}) - \sigma^a \right) \tau \right) \tag{30}$$

This result derives directly from noting that $\bar{E}(q) - q = \bar{E}(q_n) - q = \bar{E}(\sigma_{in}) - \sigma^a = 0$ when $e^a = 0$ (see Proposition 1), and from Equation (20).

So far, we have documented the strategic interaction parameters and the aggregate errors. We have found that firms hold excessively pessimistic beliefs about the aggregate impact of the carbon tax, and that quantity setting features strategic substitutabilities. According to our discussion in Section 3, pessimistic beliefs about the aggregate economy imply that firms hold pessimistic beliefs about the tax elasticity σ_{in}. We can therefore expect the noiseless expected output to be higher than the noisy one, although strategic substitutabilities should mitigate the consequences of removing noise, or even reverse it. To get both a qualitative and

quantitative assessment of the impact of removing noise, we need first to identify the information parameters, which we can do by targeting moments in the data.

7.1 Fitted moments and information parameter estimates

The estimation targets a set of moments capturing average expectations, average errors, and selected second moments. Second moments focus on cross-sectoral variances and covariances of the few variables ($q^{sc.1}$ and $q_{in}^{sc.3}$) that have homogeneous coefficients, so that these moments are not driven by the heterogeneity of the coefficients or by measurement error at the firm level.

Table 6 reports targeted and untargeted moments in the data and in the model. We minimize the sum of the squared distance between the theoretical and empirical moments. All moments are weighted with an equal weight of one, except the average expected output in Scenario 1 $\bar{E}(q)^{sc.1}$, on which we put a weight of 5, because it will be the main object of our counterfactual exercise. Overall, the model performs well in reproducing the targeted moments. In particular, it closely matches the variance of expectations about aggregate output in Scenario 1, the variance of firms' own outcomes in Scenario 3, and the covariance between the two. It also captures reasonably well the average expectations about the firms' own outcomes and the average errors in Scenario 1 and Scenario 3. Regarding errors, the model tends to match closely the error on the aggregate outcome $(\bar{E}(q)-q)^{sc.1}$ but overestimates the error on the sectoral outcome $(\bar{E}(q_n)-q)^{sc.1}$.

The model also delivers a reasonable fit for untargeted moments. Although not explicitly targeted in the estimation, the average expectations about the firms' own outcomes in Scenario 2 is broadly in line with its empirical counterpart. However, the average error on the sectoral outcomes in Scenario 2 is over-estimated. This is consistent with the model also over-estimating the sectoral error in Scenario 1, as noted above.

Table 7 reports the estimated structural parameters. First, the public prior $\sigma^a + e^a = 3.8$ is large, but half of it is due to noise e^a. The public prior is therefore excessively pessimistic. Another striking feature of the estimation is the prominent role played by sectoral information: the sectoral signal is the most precise (π^s is twice as large as π^a and 25 times larger than π^f). Besides, the volatility of the individual elasticity is driven by the individual component σ_{in}^f (κ^f, the inverse of the variance of the individual component, is four times smaller than κ^s, the inverse

of the variance of the sectoral component).

The model is non-linear and the different parameters combine in a complex way to account for the moments. However, some moments play a crucial role for some key parameters. The noise e^a is identified as being positive and relatively large. That comes from the large errors, especially $(\bar{E}(q) - q)^{sc.1}$, as suggested by Proposition 1.[7] The "true" elasticity σ^a that is estimated is the one that is both compatible with the estimated noise e^a and the large expected output drops $\bar{E}(q)^{sc.1}$ and $\bar{E}(q)^{sc.3}$.

Another key feature of the data is that the error on sectoral output $(\bar{E}(q_n) - q)^{sc.1}$ (-0.17) is low relative to the error on aggregate output $(\bar{E}(q) - q)^{sc.1}$ (-0.82). This is key for our estimation of a precise sectoral signal y_n^s. Indeed, as Proposition 1 shows, the error on sectoral output is proportional to the response of individual output to the individual signal, γ^f, while the error on aggregate output is proportional to the response of individual output to both the individual and sectoral signals, $\gamma^s + \gamma^f$. This is because, within a sector, the sectoral signal is common knowledge, so, when firms within a sector respond to sectoral information, this will not generate an error on sectoral output. By contrast, when firms in the economy respond to their sectoral signal, which is not observed by the firms in other sectors of the economy, this will generate an additional error on aggregate output. A significantly larger error on aggregate output thus means that firms respond strongly to their sectoral signal, which is compatible with a high level of precision in that signal (π^s is high).

The second moments hint at the way firms use their signals, and, indirectly, at how firms perceive the variance of noise and fundamentals. Notably, the cross-sectoral variance of the firm's own outcomes $V(E_{in}(q)^{sc.3})$ (1.9) is four times larger than the cross-sectoral variance of the firms' expectations about the aggregate outcome $V(E_{in}(q)^{sc.1})$ (0.49). This indicates that firms put a larger weight on their individual signal z_{in}^f when forming expectations about their own elasticity (which is driving their own response) than when forming expectations about the aggregate elasticity (which is driving their expectation on the aggregate output). This can be explained by a high volatility in the individual component of the elasticity σ_{in}^f

[7] Note that these large errors would also be compatible with a larger precision of the public prior π^a–i.e., with a higher weight put on the public prior–and a smaller noise e^a. The identification of precision versus noise relies on the fact that the precision affects the second moments, while noise does not.

(a low κ^f). In that case, for a given precision π^f, the individual signal is a poor signal of σ^a, because σ^f_{in} is noise, but is a good signal of $\sigma^a + \sigma^s_n + \sigma^f_{in}$ because σ_{in} is fundamental. Consistently, firms put a higher weight on that signal when inferring their own response than when inferring aggregate output, and the sectoral component in that signal then drives a higher sectoral volatility in the firm's own response.

7.2 Removing Noise

We can now quantify the role of noisy beliefs in shaping equilibrium expectations. Thanks to our estimation, we can now compute the average error the firms make on their own elasticity $\bar{E}(\sigma_{in}) - \sigma^a$ and replace in Equation (30). We also replace the errors on quantities $\bar{E}(q) - q$ and $\bar{E}(q_n) - q$ using the model-consistent values so that our counterfactual remains consistent with our estimation.[8]

Table 8 reports the aggregate noisy output, the aggregate noiseless output, the difference between the two and the contribution of each component to this difference. The first column reports the results for our baseline estimation. The expected fall in output at the firm level increases from 1.25 percentage point (pp) to 1.34pp, which amounts to a 0.09pp difference. This more pessimistic outcome is due to the fact that the revision in the expectations of the firm's own elasticity σ_{in}, which contributes to making firms more optimistic (by 0.05pp), is outweighted by the relatively larger revision in the aggregate and sectoral expectations, which, combined with strategic substitutabilities ($\alpha^a = -0.14$ and $\alpha^s = -0.30$), makes firms more pessimistic (by 0.08pp and and 0.06pp, respectively).

The firms decrease their expected elasticity expectation from 2 to 1.93, which corresponds to a 0.07 decrease in their expected elasticity. By contrast, as a result of removing noise, firms revise their expected aggregate and sectoral output upwards by 0.87pp and 0.28pp, so the strategic effects dominate. What drives this difference is the individual signal. As we have seen, according to our estimation, that signal is a good signal of the individual elasticity. When forecasting their elasticity, firms thus do not rely heavily on the public prior, so the aggregate noise cannot drive a large aggregate error on the individual elasticities. This individual signal, by contrast, is a poor signal of the aggregate and sectoral elasticities, so firms rely significantly more on the public prior when forecasting the aggregate

[8] Using the empirical errors do not significantly affect the results.

and sectoral output, allowing the aggregate noise to drive a larger error. As a result, removing noise significantly affects the firms' expectations about aggregate and sectoral output, but does not alter their own elasticity expectation that much.

The second and third columns of Table 8 examine the role of the individual signal further. Two aspects determine the quality of that signal. First, the *relevance* of the signal is determined by the variance of the individual component of the fundamental, the inverse of κ^f. In the second column, we report the results when the individual signal is less relevant, with a higher κ^f. Second, the *precision* of the signal is determined by π^f. In the second column, we report the results when the individual signal is less precise, with a lower π^f. In both cases, firms rely less on the individual signal to assess their own elasticity, and more on the public prior. Correcting the public prior has thus a stronger effect on their assessment of their own elasticity (they revise it by 0.17 and 0.18 as opposed to 0.05 in the baseline), and firms become more optimistic about their outcomes on average (by 0.08 and 0.09).

In a nutshell, our analysis shows that public information on the costs of carbon taxation are very pessimistic, reflecting a very negative global sentiment about the economic impact of carbon policies. Interestingly, noise e^a accounts for about half of the public prior on the aggregate elasticity, so that, according to that signal, the elasticity is 3.8, while the estimated true σ^a is equal to 1.9. However, the impact of that noise on the firms' expectations is mitigated because they have access to other sources of information (the sectoral and private signals).

8 Conclusion

In this paper, we propose a new survey-based methodology to recover firm-level primitives governing strategic interactions and noisy beliefs in response to a policy reform. We apply this method to the context of carbon pricing reform in Switzerland. By presenting firm managers with scenarios that vary the scope of a carbon, we can jointly identify cost semi-elasticities, strategic interaction parameters, and higher-order beliefs without imposing strong structural assumptions. The approach is portable to any policy shock with a natural scope dimension. Three main findings emerge. First, managers expect moderate but meaningful output costs due to carbon pricing: a CHF 100/ton nationwide carbon tax increase is

associated with an expected 1.14% decline in aggregate output over three years, consistent with existing estimates from observational studies. Second, we provide the first direct evidence that quantity setting features strategic substitutabilities, especially at the sectoral level. Managers who expect competitors to contract less reduce their own planned response, consistent with competitive interactions within sectors. Third, firms hold overly pessimistic beliefs about the economy-wide impact of carbon pricing—roughly half of the public prior on the aggregate elasticity reflects noise rather than fundamentals. Removing this excess pessimism would reduce the expected output decline by about 30%, after accounting for the dampening effect of strategic substitutabilities.

Our approach and results have important policy implications, especially for the design of carbon tax reforms that aim to minimize opposition by firms. Improving public information about the actual costs of carbon pricing could substantially reduce perceived output losses and lower opposition that firms might have toward carbon pricing. Future work could extend the framework to study optimal differentiated carbon taxes that balance belief correction against misallocation costs, introduce information treatments to causally test the role of aggregate beliefs, or apply the methodology to other policy contexts where strategic interactions determine firms' expectations.

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9 Tables and Figures

Table 1: Summary Statistics – Analysis Sample

	N	Mean	SD	p10	p50	p90
Panel A: Firm characteristics						
Employees (FTE)	1,145	93	344	2	18	175
Turnover (million CHF)	1,140	131.2	2980.4	0.2	4.0	48.2
Operating expenses (million CHF)	1,138	117.9	2978.8	0.1	3.1	36.0
Export share (%)	1,145	12.0	25.5	0.0	0.0	52.0
Competition intensity (1–7)	1,143	5.12	1.49	3.00	5.00	7.00
Energy share in total costs (%)	1,145	4.9	7.6	0.5	2.0	10.0
Estimated CO_2 emissions (tons)	1,143	7092	202666	1	43	822
Ideal CO_2 price for all (CHF/ton)	1,120	157	358	0	100	250
Ideal CO_2 price if exempted (CHF/ton)	1,107	165	412	0	110	300
Panel A (continued): Binary firm characteristics						
Only/mostly CH competition (0/1)	1,145	0.43				
Uses electricity (0/1)	1,145	0.94				
Uses fossil fuel (0/1)	1,145	0.70				
Uses other energy sources (0/1)	1,145	0.13				
Own CO_2 less than other firms in sector (0/1)	1,145	0.96				
Own sector CO_2 less than other sectors (0/1)	1,145	0.87				
Company subject to CO_2 tax (0/1)	1,145	0.84				
Company part of CH ETS (0/1)	1,145	0.02				
Company has made formal commitment (0/1)	1,145	0.08				
Panel B: Manager characteristics						
CEO, CFO (0/1)	1,145	0.76				
Male (0/1)	1,145	0.86				
Bachelor's degree or higher (0/1)	1,145	0.31				
Age (years)	1,140	52.6	10.1	37.0	52.0	62.0
Years at company	1,127	17.1	11.9	3.0	15.0	34.0
Survey duration (minutes)	1,142	36.9	185.7	9.1	15.9	38.1
Observations			1145			

Notes: Entries are means, standard deviations, and percentiles for the analysis sample (N = 1145). For binary (0/1) variables we report only the share. Variables marked are not yet available.

Table 2: Mean Outcomes Across Tax Levels

Panel A: Percentage Changes					
Own firm response	Tax Level (CHF/Ton CO_2)				
to a national tax	All	100	300	$\Delta_{100-300}$	p-val
Δ Energy Cost (%)	16.01	8.11	24.11	-16.00	0.00
Δ Output (%)	-1.94	-1.47	-2.42	0.95	0.01
Δ Price (%)	2.84	2.70	2.99	-0.29	0.36
Δ Energy Consumption (%)	-1.33	-1.26	-1.40	0.14	0.64
Δ FTE (%)	-1.51	-1.27	-1.75	0.48	0.10
Δ Profits (%)	-2.85	-2.41	-3.31	0.90	0.01
Panel B: Implied Elasticities					
Δ Output	-0.12	-0.18	-0.10	-0.08	0.02
Δ Price	0.18	0.33	0.13	0.21	0.00
Δ Energy Consumption	-0.08	-0.16	-0.06	-0.10	0.00
Δ FTE	-0.09	-0.16	-0.07	-0.09	0.00
Δ Profits	-0.18	-0.30	-0.14	-0.16	0.00
Observations	1,145	580	565	1,145	–

Table 3: Own Output Response and Beliefs About Responses Across Groups and Scenarios

Panel A: Own Output Across Tax Scenarios					
	National Tax	Sectoral Tax	Firm Tax	Nat – Sector	Nat – Firm
Δ Output (%)	-1.14	-1.53	-2.37	0.39*	1.23***
$\mathbf{1}\{\Delta \text{ Output} < 0\}$	0.48	0.48	0.51	.	.
$\mathbf{1}\{\Delta \text{ Output} = 0\}$	0.36	0.38	0.36	.	.
$\mathbf{1}\{\Delta \text{ Output} > 0\}$	0.16	0.14	0.13	.	.
Panel B: Own Output vs Beliefs About Others (National Tax)					
	Own Firm	Firms in Sector	Aggregate Impact	Sector – Own	Agg – Own
Δ Output (%)	-1.14	-1.32	-1.85	-0.18	-0.71***
$\mathbf{1}\{\Delta \text{ Output} < 0\}$	0.48	0.51	0.60	.	.
$\mathbf{1}\{\Delta \text{ Output} = 0\}$	0.36	0.33	0.26	.	.
$\mathbf{1}\{\Delta \text{ Output} > 0\}$	0.16	0.16	0.14	.	.

Notes: In each panel, we first report the mean percentage change in production for a given scenario normalized for 100 CHF/CO_2. We then report the share of responses that are negative, exactly zero, or positive. Most managers, nearly 50%, expect a negative impact on their own production or the production of others. Another significant share expects no impact. Finally, a small share, about 15%, expects a positive impact.

Table 4: Policy Elasticity, Strategic Interaction, and Aggregate Errors (means unweighted)

	Mean	Median	Share < 0	Share > 0
Panel A: Policy Elasticity and Strategic Interaction				
Policy elasticity $E_{in}(\sigma_{in})$	-3.46	-2.0	0.72	0.20
Sectoral-level strategic α^s_{in}	-0.47	0	0.44	0.18
Aggregate-level strategic α^a_{in}	-0.23	0	0.41	0.21
Panel B: Noisy Beliefs for Aggregate and Sectoral Outcomes				
Δ Output (%) w. National Tax	-1.15	0.00	0.47	0.16
Aggregate Error w. National Tax	-0.82	0.03	0.44	0.56
Sectoral Error w. National Tax	-0.17	0.36	0.36	0.64
Sectoral Error w. Sectoral Tax	-0.05	0.76	0.37	0.63

Notes: Panel A reports the estimates for the policy elasticity and strategic interaction parameters for the subsample of observations with non-missing values for all three parameters (N=689). Panel B, all observations can be used to compute the noisy beliefs (N=1145). To compute the noisy beliefs, the quantities q, $q_{n,1}$, and $q_{n,2}$ are a weighted sum of the firms' own responses. The weights are described in Appendix **??**.

Table 5: Heterogeneity: Strategic Interaction and Policy Elasticity Parameters

Dependent Variable	α^s_{in} (I)	$\mathbb{1}\{\alpha^s_{in} \neq 0\}$ (II)	α^a_{in} (III)	$\mathbb{1}\{\alpha^a_{in} \neq 0\}$ (IV)	σ_{in} (V)	$\mathbb{1}\{\sigma_{in} \neq 0\}$ (VI)
Full-time employees (,00000)	-16.404	-0.636	21.512	-5.217	54.154	2.898
	(14.992)	(5.547)	(16.974)	(7.081)	(51.855)	(1.925)
Turnover	0.336**	-0.053	-0.208*	0.099**	2.028***	0.010
	(0.158)	(0.065)	(0.124)	(0.044)	(0.386)	(0.017)
Export share	0.523*	-0.187**	0.378	-0.151*	1.343	0.042
	(0.288)	(0.082)	(0.266)	(0.081)	(0.938)	(0.045)
Intense compet. (bin.)	-0.080	0.090*	0.083	0.027	-1.426**	0.072**
	(0.183)	(0.047)	(0.178)	(0.046)	(0.629)	(0.030)
Only Swiss compet. (bin.)	0.183	-0.002	0.407**	-0.025	1.863***	-0.013
	(0.190)	(0.042)	(0.191)	(0.041)	(0.630)	(0.023)
Manufacturing-Machine (bin.)	-0.039	-0.017	-0.089	-0.052	0.422	-0.017
	(0.165)	(0.040)	(0.180)	(0.039)	(0.587)	(0.022)
Share of energy cost	0.000	0.001	-0.014	0.007***	0.059	0.003***
	(0.007)	(0.002)	(0.011)	(0.002)	(0.052)	(0.001)
Uses electricity (bin.)	0.043	0.014	0.342	0.012	-1.741*	-0.029
	(0.409)	(0.078)	(0.213)	(0.075)	(0.931)	(0.033)
Uses fossil (bin.)	-0.253*	-0.041	-0.131	-0.017	-1.677***	0.051*
	(0.140)	(0.044)	(0.156)	(0.044)	(0.536)	(0.029)
CO2 emissions	-4.848**	0.685	3.111*	-1.567**	-29.176***	-0.138
	(2.316)	(0.944)	(1.822)	(0.649)	(5.640)	(0.247)
Own CO2 more others (bin.)	0.100	-0.137	0.228	0.098	-1.888	-0.057
	(0.229)	(0.101)	(0.455)	(0.096)	(1.406)	(0.060)
Sector CO2 more others (bin.)	0.049	0.046	-0.121	0.013	-1.218	0.012
	(0.143)	(0.055)	(0.297)	(0.056)	(0.988)	(0.032)
CEO, Director, CFO (bin.)	0.330**	-0.021	0.219	0.013	-0.520	-0.002
	(0.166)	(0.046)	(0.219)	(0.047)	(0.743)	(0.027)
Manager: years in role	-0.003	-0.000	-0.005	0.002	0.043*	0.000
	(0.006)	(0.002)	(0.005)	(0.002)	(0.024)	(0.001)
Manager: male (bin.)	-0.185	0.049	-0.359	0.074	-0.443	0.065
	(0.210)	(0.065)	(0.234)	(0.064)	(0.892)	(0.042)
Master or PhD (bin.)	-0.661***	0.035	-0.117	0.003	-0.439	-0.057**
	(0.231)	(0.044)	(0.216)	(0.045)	(0.626)	(0.027)
High tax level (300 CHF)	-0.148	0.039	-0.107	-0.004	2.682***	0.022
	(0.125)	(0.039)	(0.139)	(0.038)	(0.568)	(0.021)
Survey duration (min)	0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Constant	-0.178	0.550***	-0.279	0.507***	-2.090	0.788***
	(0.546)	(0.118)	(0.396)	(0.115)	(1.561)	(0.065)
Observations	675	675	675	675	675	675
Adj. R-squared	0.017	-0.003	-0.003	0.013	0.082	0.027

Notes: The intensity of competition variable is a dummy variable that takes a value of one if a manager reported facing an above-average degree of competition from firms in the same sector.

Table 6: Fitted moments: data and model

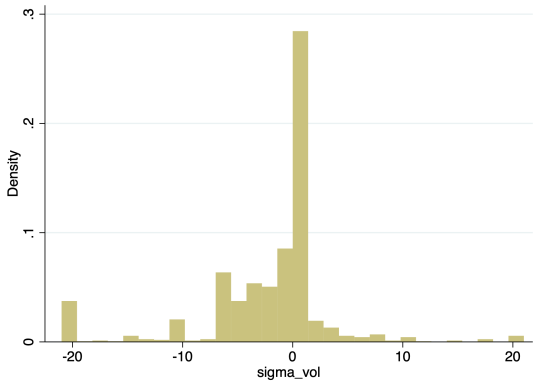
Targeted moments	**Model**	**Data**
$q^{sc.1}$	-1.25	-1.14
$(\bar{E}(q)-q)^{sc.1}$	-0.87	-0.82
$(\bar{E}(q_n)-q)^{sc.1}$	-0.28	-0.17
$\bar{E}(q)^{sc.3}$	-1.99	-2.37
$V(E_{in}(q)^{sc.1})$	0.49	0.49
$Cov(E_{in}(q)^{sc.1}, q_{in}^{sc.3})$	0.72	0.72
$V(q_{in}^{sc.3})$	1.91	1.91
Untargeted moments	**Model**	**Data**
$\bar{E}(q)^{sc.2}$	-1.75	-1.53
$(\bar{E}(q_n)-q)^{sc.2}$	-0.28	-0.05

Table 7: Estimated parameters

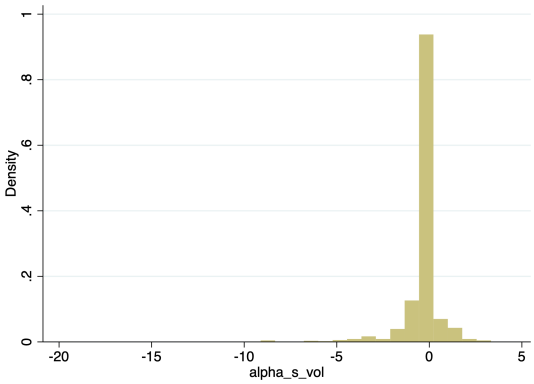
σ^a	e^a	π^a	π^s	π^f	κ^s	κ^f
1.92	1.87	0.26	0.52	0.02	0.22	0.006

Table 8: Output effect correction – Decomposition (in p.p.)

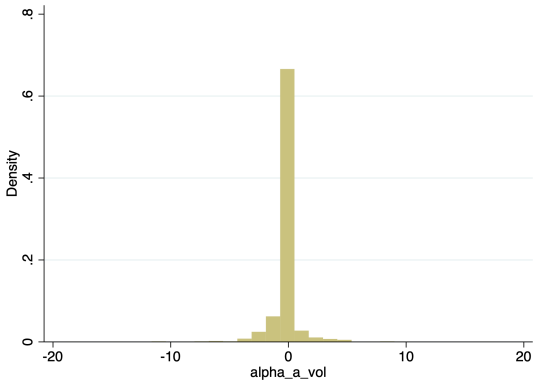
	Baseline	$\kappa^f = 0.06$	$\pi^f = 0.002$
q^{noisy}	-1.25	-1.42	-1.43
$q^{noiseless}$	-1.34	-1.34	-1.34
$q^{noiseless} - q^{noisy}$	*-0.09*	*0.08*	*0.09*
$\bar{E}(q)-q$	-0.87	-0.77	-0.76
Contribution of $\bar{E}(q)-q$	*-0.08*	*-0.07*	*-0.07*
$\bar{E}(q_n)-q$	-0.28	-0.10	-0.09
Contribution of $\bar{E}(q_n)-q$	*-0.06*	*-0.02*	*-0.02*
$\bar{E}(\sigma_{in})-\sigma^a$	0.07	0.25	0.26
Contribution of $\bar{E}(\sigma_{in})-\sigma^a$	*0.05*	*0.17*	*0.18*



(a) Policy elasticity



(b) Sectoral-level strategic



(c) Aggregate-level strategic

Figure 2: Distributions of structural parameters.

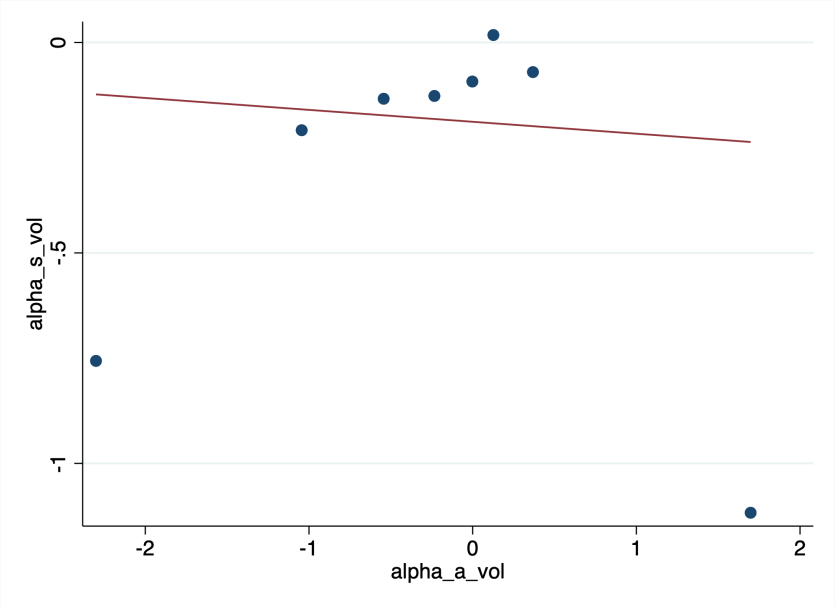
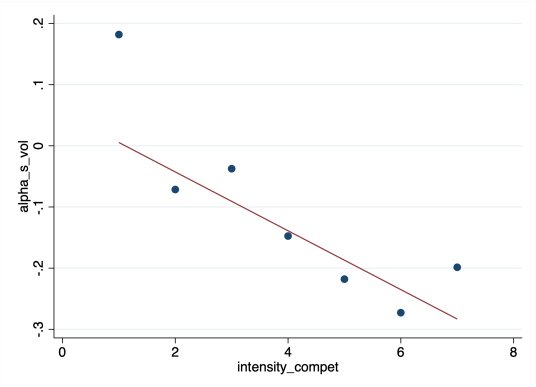
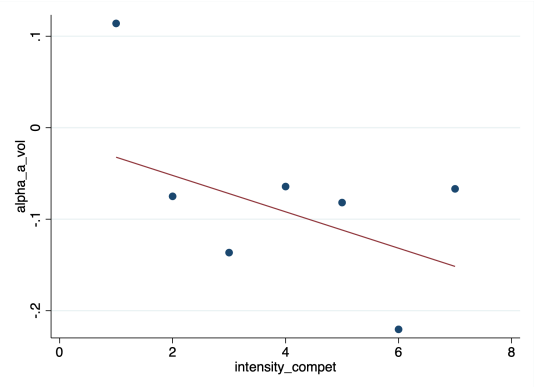


Figure 3: Strategic interaction parameters:: sectoral vs aggregate

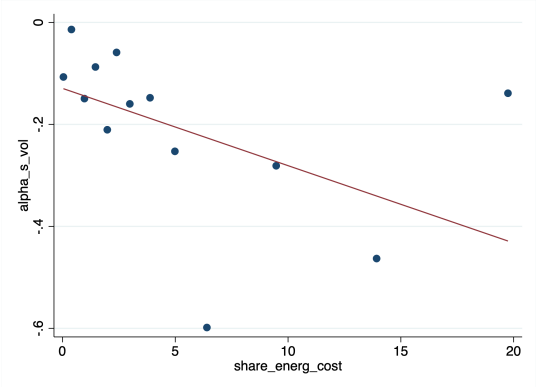
Notes: Firm managers that are the most strategic in the sectoral dimension are also the most strategic in the aggregate dimension



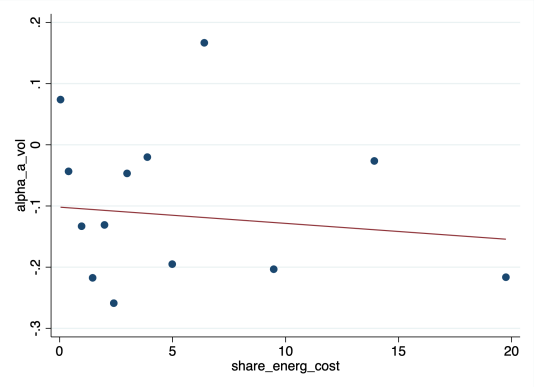
(a) Sectoral strategic parameter for output (α_s) vs. self-reported sectoral competition



(b) National strategic parameter for output (α_a) vs. self-reported sectoral competition



(c) Sectoral strategic parameter for output (α_s) vs. share of energy costs (%)



(d) National strategic parameter for output (α_a) vs. share of energy costs (%)

Figure 4: Strategic interaction parameters versus intensity of competition and energy intensity.

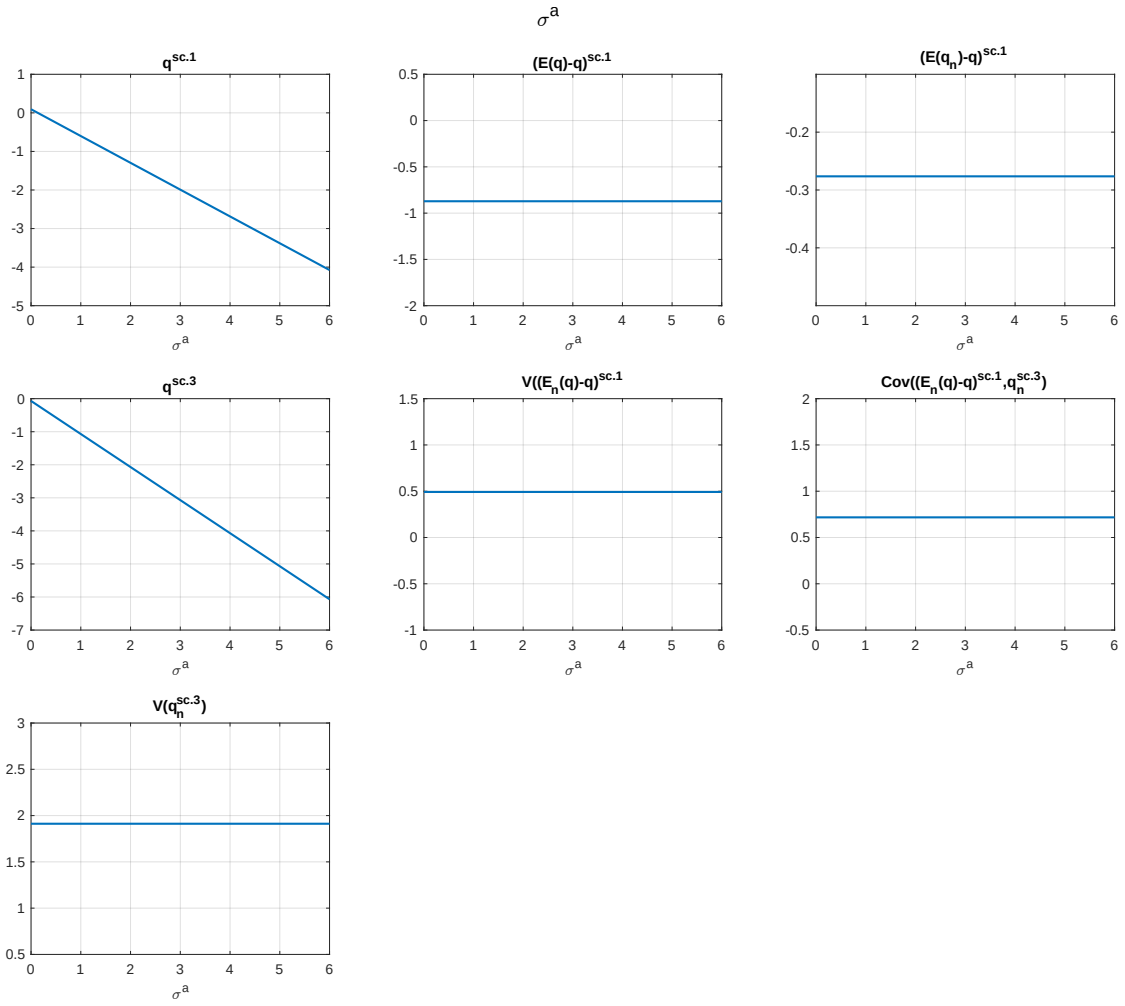


Figure 5: Impact of σ^a on the theoretical moments

Notes: Other parameters are set to their estimated level.

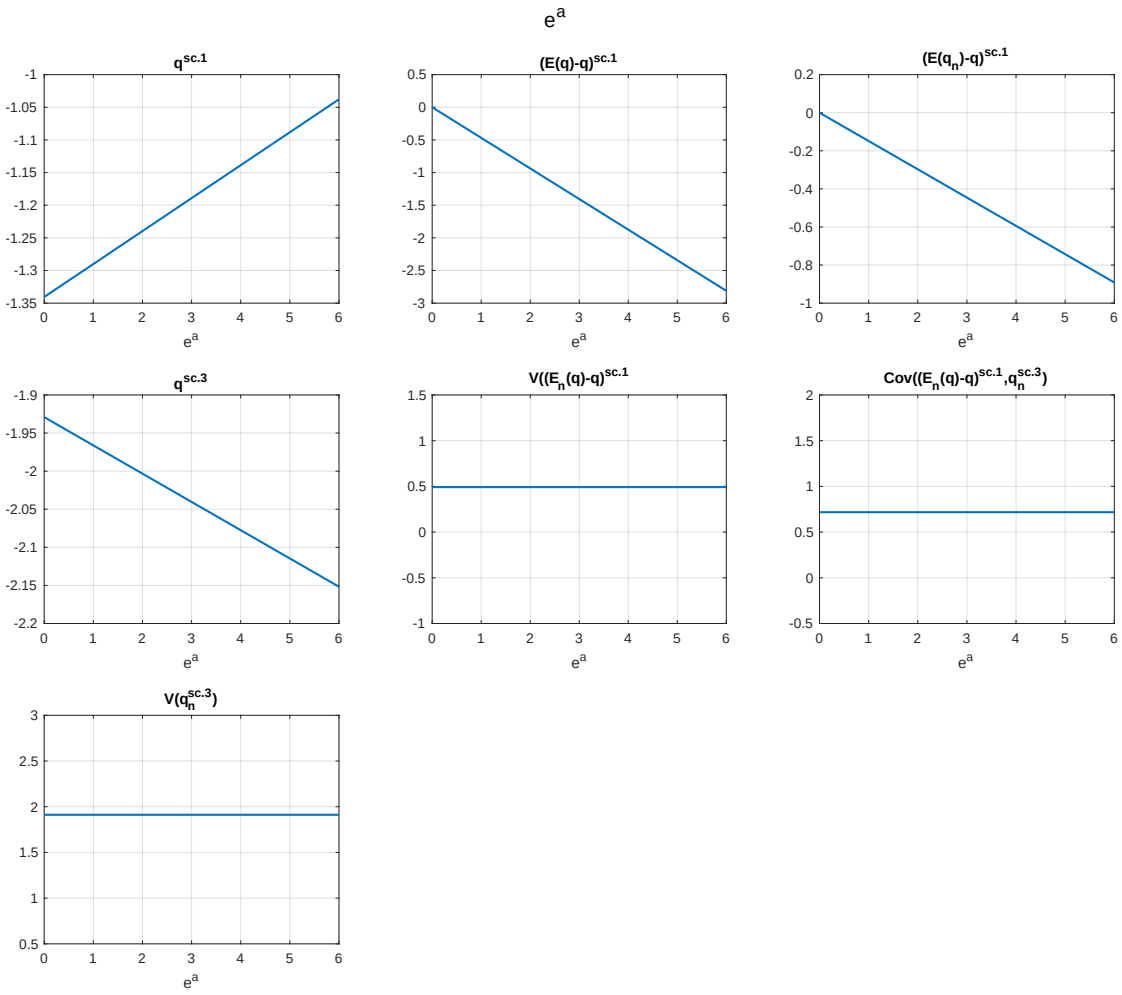


Figure 6: Impact of e^a on the theoretical moments

Notes: Other parameters are set to their estimated level.

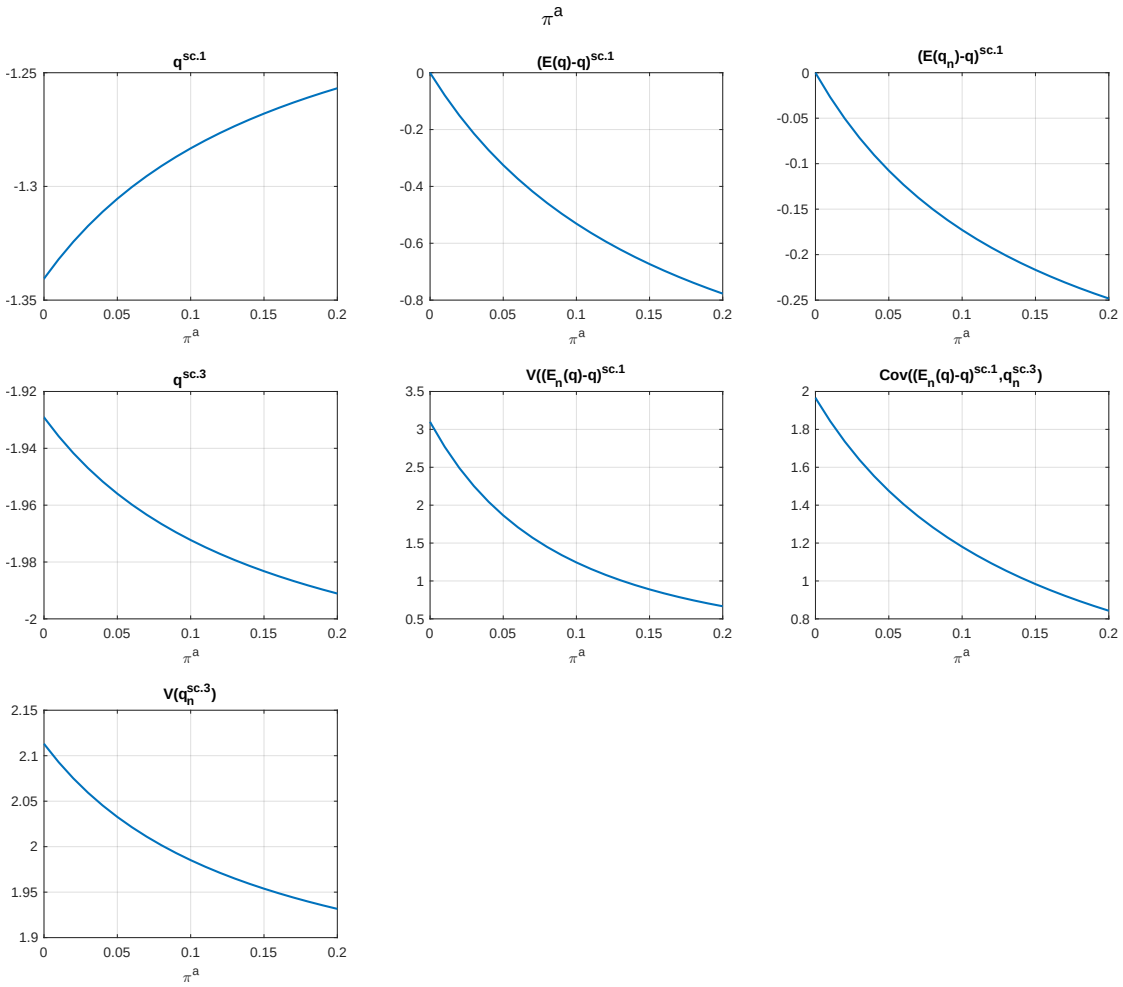


Figure 7: Impact of π^a on the theoretical moments

Notes: Other parameters are set to their estimated level.

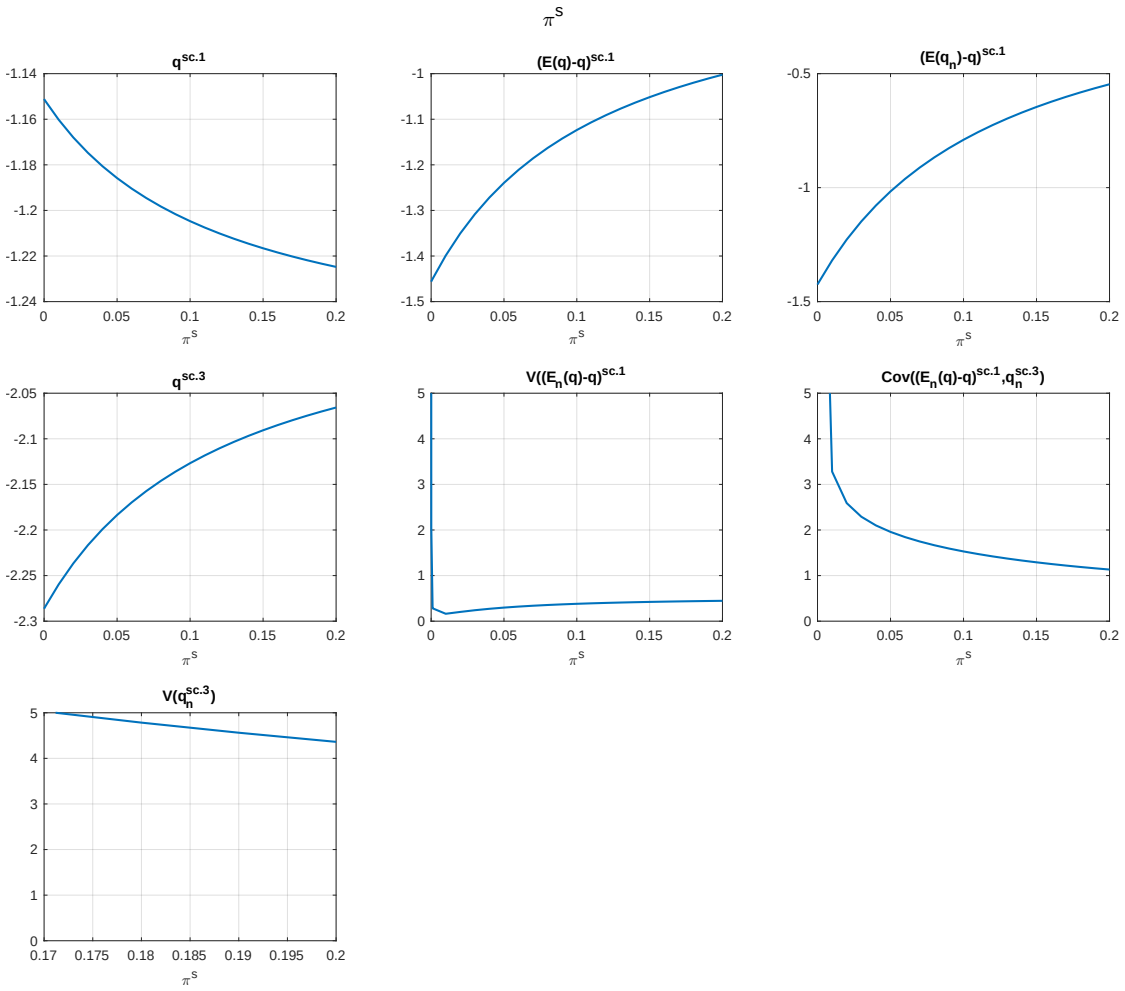


Figure 8: Impact of π^s on the theoretical moments

Notes: Other parameters are set to their estimated level.

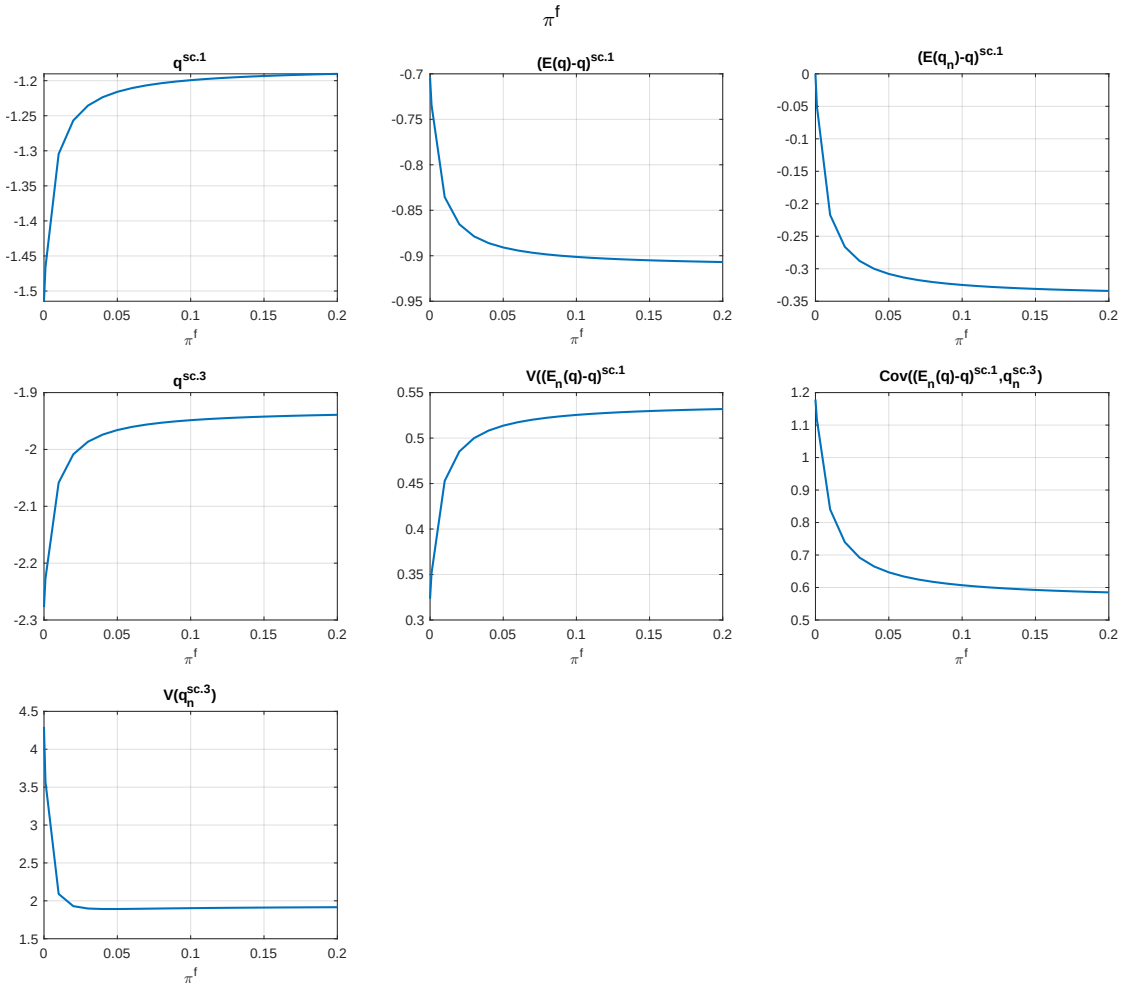


Figure 9: Impact of π^f on the theoretical moments

Notes: Other parameters are set to their estimated level.

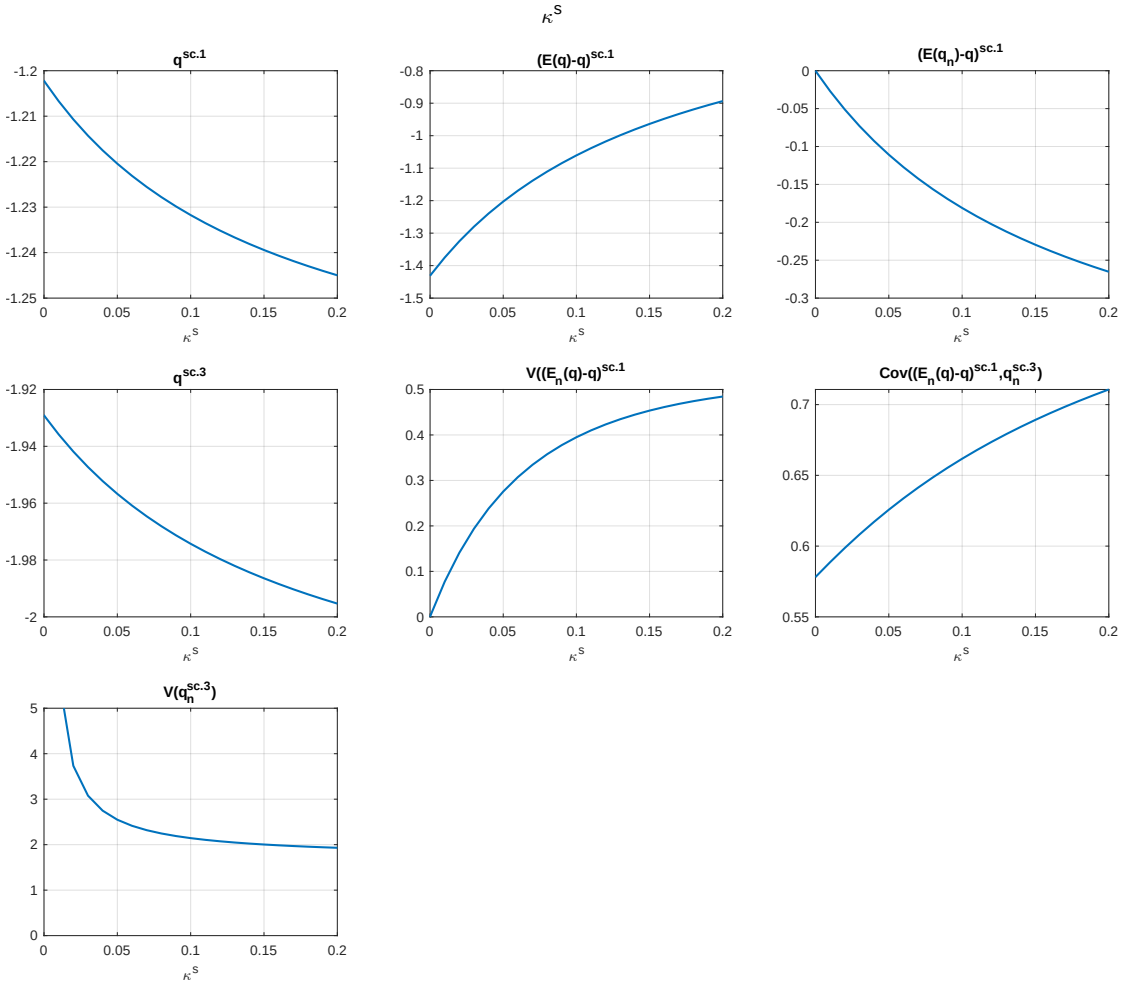


Figure 10: Impact of κ^s on the theoretical moments

Notes: Other parameters are set to their estimated level.

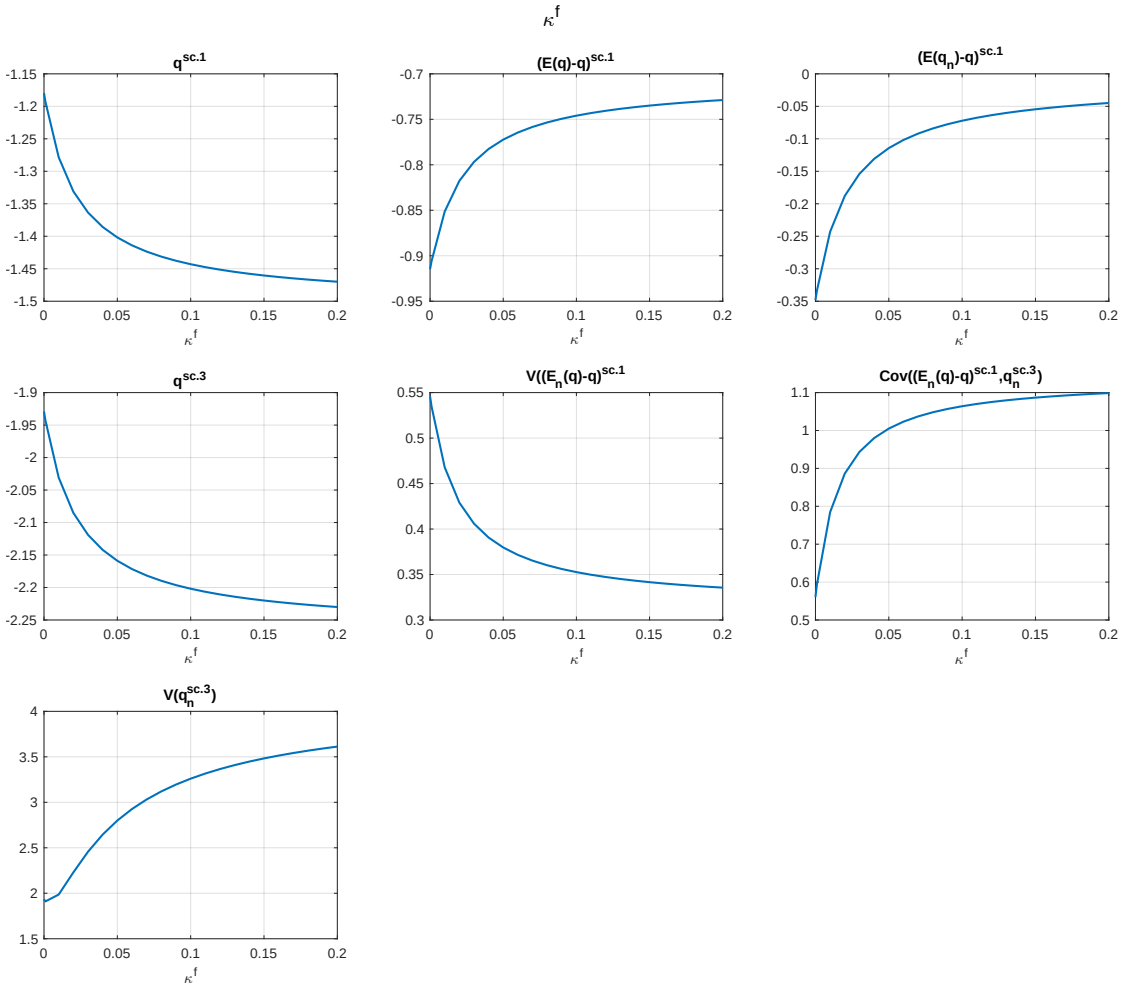


Figure 11: Impact of κ^f on the theoretical moments

Notes: Other parameters are set to their estimated level.

A Model solution

The information structure and the firm's optimal decision (18), are enough to derive the equilibrium quantities chosen by the firm.

In order to further characterize the solution, we make the following assumption:

Assumption 1 (Orders of magnitude)**.** *Define* $\alpha_{in} = (\alpha^a_{in}, \alpha^s_{in})'$*. Let* α_n *and* α *be the sectoral and economy-wide average of* α_{in}*. We assume that* $|(\alpha_{in} - \alpha_n)(\alpha_{in} - \alpha_n)'|$ *is small compared to* $|\alpha_n|$*, and* $|(\alpha_n - \alpha)(\alpha_n - \alpha)'|$ *is small compared to* $|\alpha|$*.*

We also make some independence assumption, namely, that firm-specific shocks and taxes are independent from firm-specific parameters and that sector-specific shocks and taxes are independent from sector-specific parameters (see Assumption 2 in Appendix C.2). These two assumptions ensure that any linear solution at the firm-level involving firm-level parameters can be linearly aggregated at the sector and aggregate level using sectoral and aggregate parameters. We also make some invertibility assumption that ensures the existence of a unique linear solution (see Assumption 3 in Appendix C.2).

Proposition 3. *Under Assumptions 1, 2 and 3 (see Appendix C.2 for the latter two), we can show that* $\omega = 0$*, and that the equilibrium solution for* q_{in} *is of the form*

$$q_{in} = \mathcal{Q}^{(1)}(\Theta_{in}, S_{in})\tau + \mathcal{Q}^{(2)}(\Theta_{in}, S_{in})(\tau_n - \tau) + \mathcal{Q}^{(3)}(\Theta_{in}, S_{in})(\tau_{in} - \tau_n) \tag{31}$$

where τ *and* τ_n *are the economy-wide and sectoral averages of* τ_{in} *and* $\Theta_{in} = \{\theta^\alpha, \theta^{info}\}$*, with* $\theta^\alpha = \{\alpha_{in}, \alpha_n, \alpha\}$ *the set of strategic interaction parameters,* $\theta^{info} = \{\pi^a, \pi^s, \pi^f, \kappa^f\}$ *the set of information parameters, and* $S_{in} = (x^a, E^s_n(\sigma^s_n), s^f_{in})'$ *the vector of signals. More specifically, the solution is linear in the signals, as* $\mathcal{Q}^{(j)}(\Theta_{in}, S_{in}) = A^{(j)}(\Theta_{in})S_{in}$*, for* $j = 1, 2, 3$*.*

Additionally, the equilibrium solution for firm's expectations is of the form

$$\begin{aligned} E_{in}(q_n) &= \mathcal{Q}^{s(1)}(\Theta_{in}, S_{in})\tau + \mathcal{Q}^{s(2)}(\Theta_{in}, S_{in})(\tau_n - \tau) \\ E_{in}(q) &= \mathcal{Q}^{a(1)}(\Theta_{in}, S_{in})\tau \end{aligned} \tag{32}$$

which is also linear in the signals: $\mathcal{Q}^{k(j)}(\Theta_{in}, S_{in}) = A^{k(j)}(\Theta_{in})S_{in}$*, for* $(j, k) = (1, s), (2, s), (1, a)$*.*

See proof in Appendix C.2. This proposition has two important implications. First, the proposition shows that the equilibrium output and expectations depend only on the strategic interaction parameters, the information parameters, and the signals. To perform counterfactual analysis, we thus need to identify these parameters.

Second, while the aggregate tax τ affects not only the expectation about the whole economy, but also the expectation about the sector, the sector-specific tax $\tau_n - \tau$ affects only the expectation about the sector. Besides, the firm-specific tax $\tau_{in} - \tau_n$ does not affect the expected aggregate and sectoral production, while it affects individual production. This result is quite general. It hinges only on the linearity of the model and on the fact that the tax is common knowledge. But it will be important for our identification strategy.

B Identification

According to Proposition 3, we can write P_{in} as the product of two matrices:

$$P_{in} = \underbrace{\begin{pmatrix} \tau_1 & \tau_{n,1} - \tau_1 & \tau_{in,1} - \tau_{n,1} \\ \tau_2 & \tau_{n,2} - \tau_2 & \tau_{in,2} - \tau_{n,2} \\ \tau_3 & \tau_{n,3} - \tau_3 & \tau_{in,3} - \tau_{n,3} \end{pmatrix}}_{T_{in}} \underbrace{\begin{pmatrix} \mathcal{Q}^{a(1)} & \mathcal{Q}^{s(1)} & 1 \\ 0 & \mathcal{Q}^{s(2)} & 1 \\ 0 & 0 & 1 \end{pmatrix}}_{D_{in}}$$

T_{in} is the set of alternative scenarios on the different tax components (aggregate, sector-specific and firm-specific), and D_{in} is the set of elasticities of expected aggregate and sectoral quantities, and of the individual tax to these tax components. P_{in} is invertible if and only if both T_{in} and D_{in} are invertible. D_{in} is an upper-triangular matrix invertible as long as $\mathcal{Q}^{a(1)}$ and $\mathcal{Q}^{s(2)}$ are different from zero. This is a mild assumption. Intuitively, this requires that firms believe that an economy-wide tax will have some impact on the economy in general and that a sectoral tax will have an impact on their sector.

T_{in} describes the set of tax scenarios that are provided to firms. It is invertible if we set for instance:

$$T_{in} = \begin{pmatrix} \epsilon & 0 & 0 \\ 0 & \epsilon & 0 \\ 0 & 0 & \epsilon \end{pmatrix}$$

τ_{in} is defined as the deviation of the tax from its baseline level. This amounts to presenting firms with the following three scenarios: (1) an increase ϵ in the economy-wide tax;

Well possible that I get it wrong, but the τ's used to be tax levels, right? Now, they are changes in levels, right? Does this switch from levels to changes need any further explanation?

Yes, τ is initially defined as a change in the tax relative to baseline level, which is assumed to be small (see page 4). It OK to refer to it as a tax in most cases, because the model is written in log-difference to the steady state. Here I added an extra sentence above to clarify how to interpret x.

(2) an increase ϵ in the tax in the sector where the firm operates (but not in the rest of the economy); (3) an increase ϵ in the tax that applies to the firm (but not to the rest of the economy, including the sector where the firm operates). In each of these scenarios, we ask firms about their own production, the production in their sector, and aggregate production.

Note that with these scenarios, we ensure that P_{in} is upper-triangular, with non-zero diagonal elements, as expressed by Equation (24), which ensures invertibility.

C Proofs

C.1 Preliminary results: Signal extraction

We define $S_{in} = (x^a, y_n^s, z_{in}^f)'$ as the vector of prior and signals and ξ_{in} as the vector of underlying shocks: $\xi_{in} = (\sigma^a, e^a, \sigma_n^s, e_n^s, \sigma_{in}^f, e_{in}^f)'$. Note that

$$S_{in} = H\xi_{in} \tag{33}$$

with

$$H = \begin{pmatrix} 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 \end{pmatrix}$$

The following lemma summarizes the signal extraction by firms:

Lemma 1 (Expectations)**.** *The rational expectation of* $\xi_{in} = (\sigma^a, e^a, \sigma_n^s, e_n^s, \sigma_{in}^f, e_{in}^f)'$ *by firm* i *of sector* n *conditional on* $S_{in} = (x^a, y_n^s, z_{in}^f)'$ *is given by*

$$E_{in}(\xi_{in}) = KS_{in}$$

where K is a 6×3 matrix:

$$K = \begin{pmatrix} (1-\delta_a^y-\delta_a^z) & \delta_a^y & \delta_a^z \\ \delta_a^y+\delta_a^z & -\delta_a^y & -\delta_a^z \\ -\delta_s^y-\delta_s^z & \delta_s^y & \delta_s^z \\ -(1-\delta_a^y-\delta_a^z-\delta_s^y-\delta_s^z) & 1-\delta_a^y-\delta_s^y & -\delta_a^z-\delta_s^z \\ -(\delta_f^z-\delta_f^y) & -\delta_f^y & \delta_f^z \\ -(1-\delta_a^y-\delta_a^z-\delta_s^y-\delta_s^z-(\delta_f^z-\delta_f^y)) & 1-\delta_a^y-\delta_s^y+\delta_f^y & -\delta_a^z-\delta_s^z-\delta_f^z \end{pmatrix} \tag{34}$$

with

$$\begin{aligned} \delta_a^y &= \frac{\kappa^s\pi^s(\kappa^f+\pi^f)}{\Omega} \\ \delta_a^z &= \frac{\kappa^f\kappa^s\pi^f}{\Omega} \\ \delta_s^y &= \frac{\pi^a\pi^s(\kappa^f+\pi^f)}{\Omega} \\ \delta_s^z &= \frac{\kappa^f\pi^a\pi^f}{\Omega} \\ \delta_f^y &= \frac{\pi^f\pi^s(\pi^a+\kappa^s)}{\Omega} \\ \delta_f^z &= \frac{\pi^f\pi^s(\pi^a+\kappa^s)+\kappa^s\pi^a\pi^f}{\Omega} \end{aligned} \tag{35}$$

and

$$\Omega = \kappa^f\kappa^s\pi^a + \kappa^f\kappa^s\pi^f + \kappa^f\kappa^s\pi^s + \kappa^f\pi^a\pi^f + \kappa^f\pi^a\pi^s + \kappa^s\pi^a\pi^f + \kappa^s\pi^f\pi^s + \pi^a\pi^f\pi^s$$

Proof. We are looking for the firm's posterior expectation about the components of the elasticity $\Sigma_{in} = (\sigma^a, \sigma_n^s, \sigma_{in}^f)'$, given the prior mean $(x^a, 0, 0)'$, prior variance

$$P_0 = \begin{pmatrix} (\pi^a)^{-1} & 0 & 0 \\ 0 & (\kappa^s)^{-1} & 0 \\ 0 & 0 & (\kappa^f)^{-1} \end{pmatrix}$$

and conditional on the signals $s_{in} = (y_n^s, z_{in}^f)'$.

The measurement equation is

$$s_{in} = h\Sigma_{in} + v_{in}$$

with

$$h = \begin{pmatrix} 1 & 1 & 0 \\ 1 & 1 & 1 \end{pmatrix}$$

and

$$v_{in} = \begin{pmatrix} e_n^s \\ e_{in}^f \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, R \right), \quad R = \begin{pmatrix} (\pi^s)^{-1} & 0 \\ 0 & (\pi^f)^{-1} \end{pmatrix}$$

We use the Kalman gain formula:

$$E_{in}(\Sigma_{in}) = E(\Sigma_{in}|x^a, s_{in}) = \begin{pmatrix} x^a \\ 0 \\ 0 \end{pmatrix} + k \left(s_{in} - \begin{pmatrix} x^a \\ x^a \end{pmatrix} \right)$$

with

$$k = P_0 h'(hP_0h' + R)^{-1}$$

Some computation gives us the solution for k:

$$k = \begin{pmatrix} \delta_a^y & \delta_a^z \\ \delta_s^y & \delta_s^z \\ -\delta_f^y & \delta_f^z \end{pmatrix}$$

where the δs are given in (35). This gives us the expectations on $(\sigma^a, \sigma_n^s, \sigma_{in}^f)$. Noting that

$$\begin{aligned} E_{in}(e^a) &= x^a - E_{in}(\sigma^a) \\ E_{in}(e_n^s) &= y_n^s - E_{in}(\sigma^a) - E_{in}(\sigma_n^s) \\ E_{in}(e_{in}^f) &= z_{in}^f - E_{in}(\sigma^a) - E_{in}(\sigma_n^s) - E_{in}(\sigma_{in}^f) \end{aligned}$$

we can then derive the full solution for K in Lemma 1.

□

It is useful to derive the elasticities' expectations in the following corollary:

Corollary 1 (Expectations)**.** *The expectations of the individual, sectoral, and aggregate elasticities are*

$$\begin{pmatrix} E_{in}(\sigma_{in}) \\ E_{in}(\sigma_n) \\ E_{in}(\sigma) \end{pmatrix} = \begin{pmatrix} E_{in}(\sigma^a + \sigma_n^s + \sigma_{in}^f) \\ E_{in}(\sigma^a + \sigma_n^s) \\ E_{in}(\sigma^a) \end{pmatrix} = \begin{pmatrix} \delta^x & \delta^y & \delta^z \\ \tilde{\delta}^x & \tilde{\delta}^y & \tilde{\delta}^z \\ \delta_a^x & \delta_a^y & \delta_a^z \end{pmatrix} \begin{pmatrix} x^a \\ y_n^s \\ z_{in}^f \end{pmatrix} \tag{36}$$

with

$$\begin{aligned}
\delta^y &= \delta^y_a + \delta^y_s + \delta^y_f \\
\delta^z &= \delta^z_a + \delta^z_s - \delta^z_f \\
\delta^x &= 1 - \delta^y - \delta^z \\
\tilde{\delta}^y &= \delta^y_a + \delta^y_s \\
\tilde{\delta}^z &= \delta^z_a + \delta^z_s \\
\tilde{\delta}^x &= 1 - \tilde{\delta}^y - \tilde{\delta}^z \\
\delta^x_a &= 1 - \delta^y_a - \delta^z_a
\end{aligned} \tag{37}$$

where $(\delta^y_a, \delta^y_s, \delta^y_f, \delta^z_a, \delta^z_s, \delta^z_f)$ *are given in* (35).

C.2 Proof of Proposition 3

We guess and verify that the solution is of the form

$$q_{in} = (A^{(1)}_{in} S_{in})\tau + (A^{(2)}_{in} S_{in})(\tau_n - \tau) + (A^{(3)}_{in} S_{in})(\tau_{in} - \tau_n) \tag{38}$$

with $A^{(j)}_{in} = A^{(j)}(\Theta_{in})$, for $j = 1, 2, 3$.

Define $A^{(1)}_n$, $A^{(2)}_n$ and $A^{(3)}_n$ as the sector averages of $A^{(1)}_{in}$, $A^{(2)}_{in}$ and $A^{(3)}_{in}$, and $A^{(1)}_n$, $A^{(2)}$ and $A^{(3)}$ as the economy-wide averages.

We have defined $S_{in} = (x^a, y^s_n, z^f_{in})'$ as the vector of signals and $\xi_{in} = (\sigma^a_n, e^a, \sigma^s_n, e^s_n, \sigma^f_{in}, e^f_{in})'$ as the vector of underlying shocks. Using Equation (33), our guess can be rewritten as a function of shocks:

$$q_{in} = (A^{(1)}_{in} H\xi_{in})\tau + (A^{(2)}_{in} H\xi_{in})(\tau_n - \tau) + (A^{(3)}_{in} H\xi_{in})(\tau_{in} - \tau_n) \tag{39}$$

Define Id as the 6×6 identity matrix, and Id^s and Id^a as the identity matrices that select only sectoral and aggregate shocks:

$$Id^s = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$Id^a = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Denote $\xi_n = Id^s \xi_{in}$ and $\xi = Id^a \xi_{in}$ the vectors of shocks that select only the sectoral and aggregate shocks.

We assume the following independence assumption:

Assumption 2 (Independence)**.** *The firm-specific shocks and parameters are independent: for $j = 1, 2, 3$, we have*

$$\frac{1}{N^n} \sum_i (A_{in}^{(j)} - A_n^{(j)}) H(\xi_{in} - \xi_n)(\tau_{in} - \tau_n) = 0$$
$$\frac{1}{N^n} \sum_i (A_{in}^{(j)} - A_n^{(j)}) H(\xi_{in} - \xi_n) = 0$$
$$\frac{1}{N^n} \sum_i (A_{in}^{(j)} - A_n^{(j)})(\tau_{in} - \tau_n) = 0$$
$$\frac{1}{N^n} \sum_i (\xi_{in} - \xi_n)(\tau_{in} - \tau_n) = 0$$

The sector-specific shocks and parameters are independent: for $j = 1, 2$, we have

$$\frac{1}{N} \sum_n (A_n^{(j)} - A^{(j)}) H(\xi_n - \xi)(\tau_n - \tau) = 0$$
$$\frac{1}{N} \sum_n (A_n^{(j)} - A^{(j)}) H(\xi_n - \xi) = 0$$
$$\frac{1}{N} \sum_n (A_n^{(j)} - A^{(j)})(\tau_n - \tau) = 0$$
$$\frac{1}{N} \sum_n (\xi_n - \xi)(\tau_n - \tau) = 0$$

We first establish the following lemma:

Lemma 2 (Sectoral and Economy-wide averages)**.** *Under Assumption 2,*

$$\frac{1}{N^n}\sum_i (A^{(3)}_{in} H\xi_{in})(\tau_{in}-\tau_n) = 0$$
$$\frac{1}{N^n}\sum_i (A^{(2)}_{in} H\xi_{in})(\tau_n-\tau) = (A^{(2)}_n H\xi_n)(\tau_n-\tau)$$
$$\frac{1}{N^n}\sum_i (A^{(1)}_{in} H\xi_{in})\tau = (A^{(1)}_n H\xi_n)\tau$$
$$\frac{1}{N}\sum_n (A^{(2)}_n H\xi_n)(\tau_n-\tau) = 0$$
$$\frac{1}{N}\sum_n (A^{(1)}_n H\xi_n)\tau = (A^{(1)} H\xi)\tau$$

Proof. We use the decomposition $A^l_{in} = (A^l_{in} - A^l_n) + A^l_n$ $A^l_n = (A^l_n - A^l) + A^l$, for $l = a, s, f$, $\xi_{in} = (\xi_{in} - \xi_n) + \xi_n$ and $\xi_n = (\xi_n - \xi) + \xi$, replace in the above averages, and use Assumption 2, as well as the definitions of τ, $(\tau_n - \tau)$, $(\tau_{in} - \tau_n)$, A^l_n and A^l, for $l = a, s, f$. □

We additionally assume that the following assumption is satisfied:

Assumption 3 (Invertibility)**.** $Id - \alpha^s Id^s KH - \alpha^a Id^a KH$ *and* $Id - \alpha^s_n Id^s KH$ *are invertible.*

Guess and verify Now we verify that our guess is correct.

Suppose that Equation (38) is true, then, under Assumption 2,

$$q_n = (A^{(1)}_n H\xi_n)\tau + (A^{(2)}_n H\xi_n)(\tau_n - \tau)$$
$$q = (A^{(1)} H\xi)\tau$$

Where we used Lemma 2. We then replace $\xi_n = Id^s \xi_{in}$ and $\xi = Id^a \xi_{in}$:

$$q_n = (A^{(1)}_n HId^s \xi_{in})\tau + (A^{(2)}_n HId^s \xi_{in})(\tau_n - \tau)$$
$$q = (A^{(1)} HId^a \xi_{in})\tau$$

We now take expectation and use the linearity of expectations:

$$E_{in}(q_n) = (A^{(1)}_n HId^s E_{in}(\xi_{in}))\tau + (A^{(2)}_n HId^s E_{in}(\xi_{in}))(\tau_n - \tau)$$
$$E_{in}(q) = (A^{(1)} HId^a E_{in}(\xi_{in}))\tau$$

Using Lemma 2, we obtain

$$E_{in}(q_n) = (A_n^{(1)} HId^s KS_{in})\tau + (A_n^{(2)} HId^s KS_{in})(\tau_n - \tau) \tag{40}$$

$$E_{in}(q) = (A^{(1)} HId^a KS_{in})\tau \tag{41}$$

Note also that $\sigma_{in} = X\xi_{in}$ with $X = (1, 0, 1, 0, 1, 0)$. Therefore, using similar steps, we can show

$$E_{in}(\sigma_{in}) = XKS_{in} \tag{42}$$

Now, we replace $E_{in}(q_n)$, $E_{in}(q)$ and $E_{in}(\sigma_{in})$ in Equation (18) using Equations (40), (41) and (42) and obtain

$$\begin{aligned}
q_{in} &= \alpha_{in}^a (A^{(1)} HId^a KS_{in})\tau + \alpha_{in}^s \left[(A_n^{(1)} HId^s KS_{in})\tau + (A_n^{(2)} HId^s KS_{in})(\tau_n - \tau)\right] - XKS_{in}(\tau_{in} - \tau_n) \\
&= \left[\alpha_{in}^a (A^{(1)} HId^a K) + \alpha_{in}^s (A_n^{(1)} HId^s K) - XK\right] S_{in}\tau \\
&+ \left[\alpha_{in}^s (A_n^{(2)} HId^s K) - XKH\right] S_{in}(\tau_n - \tau) \\
&- XKS_{in}(\tau_{in} - \tau_n)
\end{aligned} \tag{43}$$

Identifying each element in our guess (38) and in Equation (43), we obtain

$$A_{in}^{(1)} = \alpha_{in}^a (A^{(1)} HId^a K) + \alpha_{in}^s (A_n^{(1)} HId^s K) - XK \tag{44}$$

$$A_{in}^{(2)} = \alpha_{in}^s (A_n^{(2)} HId^s K) - XK \tag{45}$$

$$A_{in}^{(3)} = -XK \tag{46}$$

$A_{in}^{(3)}$ is explicitly defined. To find the solution for $A_{in}^{(2)}$, we solve first for $A_n^{(2)}$ by taking the sectoral average of Equation (45):

$$\begin{aligned}
A_n^{(2)} &= \alpha_n^s (A_n^{(2)} HId^s K) - XK \\
\Leftrightarrow A_n^{(2)} (Id - \alpha_n^s HId^s K) &= -XK \\
\Leftrightarrow A_n^{(2)} &= -XK(Id - \alpha_n^s HId^s K)^{-1}
\end{aligned} \tag{47}$$

where we used Assumption 3. Equation (47) gives us a solution for $A_n^{(2)}$. Then $A_{in}^{(2)}$ is simply obtained by replacing $A_n^{(2)}$ in Equation (45).

To find the solution for $A_{in}^{(1)}$, we solve first for $A^{(1)}$ by taking the economy-wide average of Equation (44):

$$\begin{aligned}
A^{(1)} &= \alpha^a (A^{(1)} HId^a K) + \alpha^s (A^{(1)} HId^s K) - XK \\
\Leftrightarrow A^{(1)} (Id - \alpha^s HId^s K - \alpha^a HId^a K) &= -XK \\
\Leftrightarrow A^{(1)} &= -XK(Id - \alpha^s HId^s K - \alpha^a HId^a K)^{-1}
\end{aligned} \tag{48}$$

where we used Assumptions 1 and 3. We use Assumption 1 to approximate $\frac{1}{N}\sum_{n=1}^{N}\alpha_n^s A_n^{(1)} \simeq \alpha^s A^{(1)}$. Indeed,

$$\begin{aligned}
A_{in}^{(1)} =& A^{(1)}(\Theta_{in}) = A^{(1)}(\theta_{in}^{\alpha}, \theta^{info}) \\
\simeq& A^{(1)} + (\alpha_{in}^a - \alpha_n^a)\frac{\partial A^{(1)}}{\partial(\alpha_{in}^a - \alpha_n^a)} + (\alpha_{in}^s - \alpha_n^s)\frac{\partial A^{(1)}}{\partial(\alpha_{in}^s - \alpha_n^s)} \\
&+ (\alpha^a - \alpha_n^a)\frac{\partial A^{(1)}}{\partial(\alpha^a - \alpha_n^a)} + (\alpha^s - \alpha_n^s)\frac{\partial A^{(1)}}{\partial(\alpha^s - \alpha_n^s)}
\end{aligned}$$

where $A^{(1)}$ is the value of $A^{(1)}(\Theta_{in})$ when $\alpha_{in} = \alpha_n = \alpha$, with α the economy-wide average of α_{in}. Therefore, $A_n^{(1)}$, the sectoral average of $A_{in}^{(1)}$ can be approximated as

$$A_n^{(1)} \simeq A^{(1)} + (\alpha^a - \alpha_n^a)\frac{\partial A^{(1)}}{\partial(\alpha^a - \alpha_n^a)} + (\alpha^s - \alpha_n^s)\frac{\partial A^{(1)}}{\partial(\alpha^s - \alpha_n^s)}$$

As a result,

$$\begin{aligned}
\frac{1}{N}\sum_{n=1}^{N}\alpha_n^s A_n^{(1)} =& \frac{1}{N}\sum_{n=1}^{N}\alpha^s A_n^{(1)} + \frac{1}{N}\sum_{n=1}^{N}(\alpha_n^s - \alpha^s)A_n^{(1)} \\
=& \alpha^s A^{(1)} + \underbrace{\frac{1}{N}\sum_{n=1}^{N}(\alpha_n^s - \alpha^s)A^{(1)}}_{=0} + \frac{1}{N}\sum_{n=1}^{N}(\alpha_n^s - \alpha^s)(A_n^{(1)} - A^{(1)}) \\
\simeq& \alpha^s A^{(1)} + \frac{1}{N}\sum_{n=1}^{N}(\alpha_n^s - \alpha^s)\left((\alpha^a - \alpha_n^a)\frac{\partial A^{(1)}}{\partial(\alpha^a - \alpha_n^a)} + (\alpha^s - \alpha_n^s)\frac{\partial A^{(1)}}{\partial(\alpha^s - \alpha_n^s)}\right) \\
\simeq& \alpha^s A^{(1)}
\end{aligned}$$

where the last line is a direct consequence of Assumption 1. This enables us to aggregate equation (44) into the simple linear expression (48).

Equation (48) then gives us a solution for $A^{(1)}$. To find $A_n^{(1)}$, we use the sectoral average of Equation (44):

$$\begin{aligned}
& A_n^{(1)} = \alpha_n^a(A^{(1)}HId^aK) + \alpha_n^s(A_n^{(1)}HId^sK) - XK \\
\Leftrightarrow\ & A_n^{(1)}(Id - \alpha_n^s HId^sK) = \alpha_n^a(A^{(1)}HId^aK) - XK \\
\Leftrightarrow\ & A_n^{(1)} = \left[\alpha_n^a(A^{(1)}HId^aK) - XK\right](Id - \alpha_n^s HId^sK)^{-1}
\end{aligned} \tag{49}$$

where we used Assumption 3. Equation (49) gives us a solution for $A_n^{(1)}$. Then $A_{in}^{(1)}$ is simply obtained by replacing $A^{(1)}$ and $A_n^{(1)}$ in Equation (44).

Combining Equations (44) to (49), we can show that the solution for $(A_{in}^{(1)}, A_{in}^{(2)}, A_{in}^{(3)})$ is

$$\begin{aligned}
A_{in}^{(1)} &= -XK\left[Id + \alpha_n^a(Id - \alpha^s HId^s K - \alpha_n^a HId^a K)^{-1} Id^a K\right]\left[Id + \alpha_{in}^s(Id - \alpha_n^s HId^s K)^{-1} Id^s K\right] \\
&\quad - XK(\alpha_{in}^a - \alpha_n^a)(Id - \alpha^s HId^s K - \alpha_n^a HId^a K)^{-1} Id^a K \\
A_{in}^{(2)} &= -XK\left[Id + \alpha_{in}^s(Id - \alpha_n^s HId^s K)^{-1} Id^s K\right] \\
A_{in}^{(3)} &= -XK
\end{aligned} \tag{50}$$

This satisfies our guess and provides an explicit solution for Equation (38).

Then, Equation (31) can be derived, with $\mathcal{Q}^{(j)}(\Theta_{in}, S_{in}) = A^{(j)}(\Theta_{in})S_{in}$, $j = 1, 2, 3$, with $A^{(j)}(\Theta_{in}) = A_{in}^{(j)}$, as defined in (50).

Equations (32) can be obtained by aggregating Equation (38) at the sectoral and aggregate levels, using Assumption 2:

$$\begin{aligned}
q_n &= (A_n^{(1)} H\xi_n)\tau + (A_n^{(2)}\xi_n)(\tau_n - \tau) \\
q &= (A^{(1)} H\xi)\tau
\end{aligned}$$

We take expectations:

$$\begin{aligned}
E_{in}(q_n) &= A_n^{(1)} HE_{in}(\xi_n)\tau + A_n^{(2)} HE_{in}(\xi_n)(\tau_n - \tau) \\
E_{in}(q) &= A^{(1)} HE_{in}(\xi)\tau
\end{aligned}$$

We then use Lemma 1 to replace the expectations in the right-hand side:

$$\begin{aligned}
E_{in}(q_n) &= A_n^{(1)} Id^s HKS_{in}\tau + A_n^{(2)} Id^s HKS_{in}(\tau_n - \tau) \\
E_{in}(q) &= A^{(1)} Id^a HKS_{in}\tau
\end{aligned}$$

We thus have

$$\begin{aligned}
E_{in}(q_n) &= A_n^{s(1)} S_{in}\tau + A_n^{s(2)} S_{in}(\tau_n - \tau) \\
E_{in}(q) &= A^{a(1)} S_{in}\tau
\end{aligned}$$

with

$$\begin{aligned}
A_n^{s(1)} &= A_n^{(1)} Id^s HK \\
A_n^{s(2)} &= A_n^{(2)} Id^s HK \\
A^{a(1)} &= A^{(1)} Id^a HK
\end{aligned} \tag{51}$$

Therefore, Equations (32) are satisfied, with $\mathcal{Q}^{k(j)}(\Theta_{in}, S_{in}) = A^{k(j)}(\Theta_{in})S_{in}$, for $(j, k) = (1, s), (2, s), (1, a)$, with $A^{s(1)}(\Theta_{in}) = A_n^{s(1)}$, $A^{s(2)}(\Theta_{in}) = A_n^{s(2)}$ and $A^{a(1)}(\Theta_{in}) = A^{a(1)}$ as defined in (51).

C.3 Proof of Proposition 1

We prove Proposition 1 in four steps.

Step 1: Error on elasticity According to Corollary 1, the firm expectation on its elasticity σ_{in} is

$$\begin{aligned} E_{in}(\sigma_{in}) &= E_{in}(\sigma^a) + E_{in}(\sigma_n^s) + E_{in}(\sigma_{in}^f) \\ &= \delta^x x^a + \delta^y y_n^s + \delta^z z_{in}^f \end{aligned} \tag{52}$$

Aggregating across all firms:

$$E_{in}(\sigma_{in}) = \sigma^a + \delta^x e^a$$

which yields Equation (21).

Step 2: Errors on quantities Proposition 3 implies that the solution for q_{in}, in the case of an economy-wide tax τ, is of the form

$$q_{in} = -[\gamma_{in}^x x^a + \gamma_{in}^y y_n^s + \gamma_{in}^z z_{in}^f]\tau \tag{53}$$

Simply put, the output response is a linear combination of the firm's signals and prior.[9] Among these, x^a is common knowledge in the whole economy, y_n^s is private to the sector but common knowledge within the sector and z_{in}^f is private to the firm.

Assuming that Assumption 2 holds, and aggregating at the sector and aggregate level implies that the following expressions hold for output at the sector and aggregate level.

$$q_n = -[\gamma_n^x x^a + \gamma_n^y y_n^s + \gamma_n^z(\sigma^a + \sigma_n^s)]\tau \tag{54}$$

$$q = -[\gamma^x x^a + (\gamma^y + \gamma^z)\sigma^a]\tau \tag{55}$$

When summing these individual quantities across firms, the private signals sum to the fundamental value of the aggregate elasticity σ^a at the aggregate level and to the sectoral elasticity $\sigma^a + \sigma_n^s$ at the sectoral level.

[9] This corresponds to the solution (31) with $\tau_n - \tau = 0$, $\tau_{in} - \tau_n = 0$, and $\mathcal{Q}^{(1)} = A^{(1)} S_{in}$ with $A^{(1)} = (-\gamma_{in}^x, -\gamma_{in}^y, -\gamma_{in}^z)'$.

When forming an expectation of the aggregate output q, (a higher-order belief), firms must not only forecast the part that they know, x^a (because it is public information), but also the part that they don't know, σ^a (because it arises from the others' private information). As a consequence, the error on q is driven by the error on σ^a, but only to the extent that q depends on the firms' private individual and sectoral information ($\gamma^z + \gamma^y \neq 0$):

$$E_{in}(q) - q = -(\gamma^z + \gamma^y)[E_{in}(\sigma^a) - \sigma^a]\tau$$

The aggregate error is then

$$\bar{E}(q) - q = -(\gamma^z + \gamma^y)[\bar{E}(\sigma^a) - \sigma^a]\tau = -(\gamma^z + \gamma^y)\delta_a^x e^a \tau \tag{56}$$

where we used Corollary 1.

Similarly, the expectation error about sectoral output can be expressed as a function of the errors on both the aggregate and sectoral components:

$$E_{in}(q_n) - q_n = -\gamma_n^z[E_{in}(\sigma^a) - \sigma^a + E_{in}(\sigma_n^s) - \sigma_n^s]\tau$$

The aggregate error on sectoral output is then

$$\bar{E}(q_n) - q = -\gamma^z \tilde{\delta}^x e^a \tau \tag{57}$$

where we used Corollary 1.

Equations (56) and (57) correspond to Equations (22) and (23) of Proposition 1.

Step 3: Sign of γ^z and γ^y We now derive a closed-form expressions for γ^z and γ^y.

Taking expectations, and using the solution for expectations from Corollary 1, we obtain

$$\begin{aligned}
E_{in}(q_n) &= -\left(\gamma_n^x x^a + \gamma_n^y y_n^s + \gamma_n^z (E_{in}(\sigma^a) + E_{in}(\sigma_n^s))\right)\tau \\
&= -\left(\gamma_n^x x^a + \gamma_n^y y_n^s + \gamma_n^z \tilde{\delta}^x x^a + \tilde{\delta}^y y_n^s + \tilde{\delta}^z z_{in}^f)\right)\tau \\
&= -\left((\gamma_n^x + \gamma_n^z \tilde{\delta}^x)x^a + (\gamma_n^y + \gamma_n^z \tilde{\delta}^y)y_n^s + \gamma_n^z \tilde{\delta}^z z_{in}^f\right)\tau \\
E_{in}(q) &= -\left(\gamma^x x^a + (\gamma^y + \gamma^z)E_{in}(\sigma^a)\right)\tau \\
&= -\left(\gamma^x x^a + (\gamma^y + \gamma^z)[\delta_a^x x^a + \delta_a^y y_n^s + \delta_a^z z_{in}^f]\right)\tau \\
&= -\left((\gamma^x + \gamma^z \delta_a^x)x^a + (\gamma^y + \gamma^z)\delta_a^y y_n^s + (\gamma^y + \gamma^z)\delta_a^z z_{in}^f\right)\tau
\end{aligned}$$

Using these expressions, along with (52), we can substitute the terms in Equation (18) and obtain:

$$\begin{aligned} q_{in} = &- \alpha_{in}^{a}\left((\gamma^{x}+\gamma^{z}\delta_{a}^{x})x^{a}+(\gamma^{y}+\gamma^{z})\delta_{a}^{y}y_{n}^{s}+(\gamma^{y}+\gamma^{z})\delta_{a}^{z}z_{in}^{f}\right)\tau \\ &- \alpha_{in}^{s}\left((\gamma_{n}^{x}+\gamma_{n}^{z}\tilde{\delta}^{x})x^{a}+(\gamma_{n}^{y}+\gamma_{n}^{z}\tilde{\delta}^{y})y_{n}^{s}+\gamma_{n}^{z}\tilde{\delta}^{z}z_{in}^{f}\right)\tau \\ &- \left(\delta^{x}x^{a}+\delta^{y}y_{n}^{s}+\delta^{z}z_{in}^{f}\right)\tau \\ = &- \left(\alpha_{in}^{a}(\gamma^{x}+\gamma^{z}\delta_{a}^{x})+\alpha_{in}^{s}(\gamma_{in}^{x}+\gamma_{n}^{z}\tilde{\delta}^{x})+\delta^{x}\right)x^{a}\tau \\ &- \left(\alpha_{in}^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{y}+\alpha_{in}^{s}(\gamma_{n}^{y}+\gamma_{n}^{z}\tilde{\delta}^{y})+\delta^{y}\right)y_{n}^{s}\tau \\ &- \left(\alpha_{in}^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{z}+\alpha_{in}^{s}\gamma_{n}^{z}\tilde{\delta}^{z}+\delta^{z}\right)z_{in}^{f}\tau \end{aligned}$$

Identifying the coefficients of y_n^s and z_{in}^f across the above expression and (62), we obtain:

$$\begin{aligned} \gamma_{in}^{y} =& \alpha_{in}^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{y}+\alpha_{in}^{s}(\gamma_{n}^{y}+\gamma_{n}^{z}\tilde{\delta}^{y})+\delta^{y} \\ \gamma_{in}^{z} =& \alpha_{in}^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{z}+\alpha_{in}^{s}\gamma_{n}^{z}\tilde{\delta}^{z}+\delta^{z} \end{aligned} \tag{58}$$

These equations can be aggregated at the sector level:

$$\begin{aligned} \gamma_{n}^{y} =& \alpha_{n}^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{y}+\alpha_{n}^{s}(\gamma_{n}^{y}+\gamma_{n}^{z}\tilde{\delta}^{y})+\delta^{y} \\ \gamma_{n}^{z} =& \alpha_{n}^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{z}+\alpha_{n}^{s}\gamma_{n}^{z}\tilde{\delta}^{z}+\delta^{z} \end{aligned} \tag{59}$$

Under Assumption 1, we can approximate:

$$\frac{1}{N}\sum_{n=1}^{N}\alpha_{n}^{s}\gamma_{n}^{y}\simeq\alpha^{s}\gamma^{y}, \qquad \frac{1}{N}\sum_{n=1}^{N}\alpha_{n}^{s}\gamma_{n}^{z}\simeq\alpha^{s}\gamma^{z}$$

To show this, we follow the same steps as in the proof of Proposition 3. As a result, the sectoral equations can be aggregated as follows:

$$\begin{aligned} \gamma^{y} =& \alpha^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{y}+\alpha^{s}(\gamma^{y}+\gamma^{z}\tilde{\delta}^{y})+\delta^{y} \\ \gamma^{z} =& \alpha^{a}(\gamma^{y}+\gamma^{z})\delta_{a}^{z}+\alpha^{s}\gamma^{z}\tilde{\delta}^{z}+\delta^{z} \end{aligned} \tag{60}$$

After some further manipulation of these equations, we can show that

$$\begin{aligned} \gamma^{y}+\gamma^{y} =& \frac{(1-\alpha^{s}\tilde{\delta}^{z})\delta^{y}+(1-\alpha^{s}(1-\tilde{\delta}^{y}))\delta^{z}}{(1-\alpha^{s}\tilde{\delta}^{z})(1-\alpha^{a}(\delta_{a}^{y}+\delta_{a}^{z})-\alpha^{s})+\alpha^{a}\delta_{a}^{z}\alpha^{s}(1-\tilde{\delta}^{y}-\tilde{\delta}^{z})} \\ \gamma^{z} =& \frac{(1-\alpha^{a}\delta_{a}^{y}-\alpha^{s})\delta^{z}+\alpha^{a}\delta^{y}\delta_{a}^{z}}{(1-\alpha^{s}\tilde{\delta}^{z})(1-\alpha^{a}(\delta_{a}^{y}+\delta_{a}^{z})-\alpha^{s})+\alpha^{a}\delta_{a}^{z}\alpha^{s}(1-\tilde{\delta}^{y}-\tilde{\delta}^{z})} \end{aligned} \tag{61}$$

These two coefficients share the same denominator. We can show that this denominator is positive when $|\alpha^a|^{\frac{1}{2}} + |\alpha^s|^{\frac{1}{2}} < 1$:

$$\begin{aligned}(1-\alpha^s\tilde{\delta}^z)(1-\alpha^a(\delta_a^y+\delta_a^z)-\alpha^s)+\alpha^a\delta_a^z\alpha^s(1-\tilde{\delta}^y-\tilde{\delta}^z) &\geq (1-|\alpha^s|)(1-|\alpha^a|-|\alpha^s|)-|\alpha^a||\alpha^s| \\ &\geq 1-|\alpha^a|-2|\alpha^s|+|\alpha^s|^2 \\ &\geq (1-|\alpha^s|)^2-|\alpha^a|\end{aligned}$$

We used the fact that $\tilde{\delta}^z$, $\delta_a^y+\delta_a^z$, δ_a^z and $1-\tilde{\delta}^y-\tilde{\delta}^z$ are positive and lower than one, and the fact that $|\alpha^a|^{\frac{1}{2}} + |\alpha^s|^{\frac{1}{2}} < 1$ implies that $|\alpha^a| < 1$, $|\alpha^s| < 1$ and $|\alpha^a| + |\alpha^s| < 1$.

Now, notice that $|\alpha^s|^{\frac{1}{2}} > |\alpha^s|$. As a result, $|\alpha^a|^{\frac{1}{2}} + |\alpha^s| < |\alpha^a|^{\frac{1}{2}} + |\alpha^s|^{\frac{1}{2}} < 1$, yielding $1-|\alpha^s| > |\alpha^a|^{\frac{1}{2}}$, and hence $(1-|\alpha^s|)^2 > |\alpha^a|$. This implies that the denominator is strictly positive.

Using similar arguments, we can show that the numerator of $\gamma^y+\gamma^z$ is strictly positive:

$$(1-\alpha^s\tilde{\delta}^z)\delta^y+(1-\alpha^s(1-\tilde{\delta}^y))\delta^z \geq (1-|\alpha^s|)\delta^y+(1-|\alpha^s|)\delta^z \geq 0$$

and that the numerator of γ^z is strictly positive:

$$\begin{aligned}(1-\alpha^a\delta_a^y-\alpha^s)\delta^z+\alpha^a\delta^y\delta_a^z &= \left(1-\alpha^a\left(\delta_a^y-\delta^y\frac{\delta_a^z}{\delta^z}\right)-\alpha^s\right)\delta^z \\ &\geq (1-|\alpha^a|-|\alpha^s|)\delta^z \geq 0\end{aligned}$$

where we used the fact that δ_a^z/δ^z is between zero and one.

Consequently, both $\gamma^y+\gamma^z$ and γ^z are positive.

Step 4: The role of private information Remember that, according to Corollary 1, $\delta^y+\delta^z = \delta_a^y+\delta_s^y-\delta_f^y+\delta_a^z+\delta_s^z+\delta_f^z$ and $\delta^x = 1-\delta^y-\delta^z$. Using Lemma 1, this implies that

$$\delta^x = \frac{\kappa^f\kappa^s\pi^a}{\Omega}$$

As a consequence, δ^x goes to zero when either π^f goes to infinity or π^s goes to infinity.

If $\pi^f = 0$, then, using Lemma 1 and Corollary 1, we can show that $\delta^z = \delta_a^z = 0$, and therefore, according to (61), $\gamma^z = 0$. Similarly, if $\pi^f = \pi^s = 0$, then $\delta^y = \delta^z = 0$ and $\gamma^y+\gamma^z = 0$.

C.4 Proof of Equation (27)

Proposition 3 implies that the solution for q_{in}, in the case of an sectoral tax $\tau_n - \tau$, is of the form

$$q_{in} = -[\tilde{\gamma}^x_{in} x^a + \tilde{\gamma}^y_{in} y^s_n + \tilde{\gamma}^z_{in} z^f_{in}](\tau_n - \tau) \tag{62}$$

The output response is a linear combination of the firm's signals.[10] Among these signals, two are common knowledge within the sector (x^a and s^s_n) and one is private (z^f_{in}).

Assuming that Assumption 2 holds, and aggregating at the sector level implies that the following expression holds for output at the sector level.

$$q_n = -[\tilde{\gamma}^x_n x^a + \tilde{\gamma}^y_n y^s_n + \tilde{\gamma}^z_n(\sigma^a + \sigma^s_n)](\tau_n - \tau) \tag{63}$$

When summing the individual quantities across firms, the private signals sum to the sectoral elasticity $\sigma^a + \sigma^s_n$ at the sectoral level.

The expectation error about sectoral output can be expressed as a function of the errors on both the aggregate and sectoral components:

$$E_{in}(q_n) - q_n = -\tilde{\gamma}^z_n[E_{in}(\sigma^a) - \sigma^a + E_{in}(\sigma^s_n) - \sigma^s_n](\tau_n - \tau)$$

Note that, under scenario 2, firms responses all correspond to the case where $\tau_n - \tau = x$. Aggregating across all firms, we thus obtain that the aggregate error on the sectoral output response to a sectoral tax of x is

$$\bar{E}(q_{n,2}) - q_2 = -\tilde{\gamma}^z \tilde{\delta}^x e^a(\tau_n - \tau) \tag{64}$$

where we used Corollary 1. This corresponds to Equation (27).

Using similar steps as for Step 3 of the proof of Proposition 1, we obtain

$$\tilde{\gamma}^z = \frac{\delta^z}{1 - \alpha^s \tilde{\delta}^z} \tag{65}$$

Similarly, under the assumption that $|\alpha^a|^{\frac{1}{2}} + |\alpha^s|^{\frac{1}{2}} < 1$, we can show that $\tilde{\gamma}^z \geq 0$.

[10] This corresponds to the solution (31) with $\tau = 0$, $\tau_{in} - \tau_n = 0$, and $\mathcal{Q}^{(2)} = A^{(2)} S_{in}$ with $A^{(2)} = (-\tilde{\gamma}^x_{in}, -\tilde{\gamma}^y_{in}, -\tilde{\gamma}^z_{in})'$.

Table 9: Summary Statistics by Sample

	Incomplete		End of Survey		Complete	
	Mean	N	Mean	N	Mean	N
Panel A: Firm characteristics						
Employees (FTE)	175	2,589	92	1,408	93	1,145
Turnover (million CHF)	198.8	1,230	110.2	1,402	131.2	1,140
Operating expenses (million CHF)	17.8	944	98.0	1,398	117.9	1,138
Export share (%)	5.0	2,708	12.1	1,408	12.0	1,145
Competition intensity (1–7)	5.00	1,174	5.10	1,403	5.12	1,143
Energy share in total costs (%)	2.3	2,708	5.4	1,408	4.9	1,145
Estimated CO_2 emissions (tons)	1963	803	5893	1,403	7092	1,143
Ideal CO_2 price for all (CHF/ton)	106	33	158	1,363	157	1,120
Ideal CO_2 price if exempted (CHF/ton)	106	33	2172	1,346	165	1,107
Panel A (continued): Binary firm characteristics						
Only/mostly CH competition (0/1)	0.48	1,190	0.45	1,408	0.43	1,145
Uses electricity (0/1)	0.90	883	0.94	1,408	0.94	1,145
Uses fossil fuel (0/1)	0.61	883	0.69	1,408	0.70	1,145
Uses other energy sources (0/1)	0.13	883	0.13	1,408	0.13	1,145
Own CO_2 less than other firms in sector (0/1)	1.00	32	0.97	1,408	0.96	1,145
Own sector CO_2 less than other sectors (0/1)	0.90	31	0.88	1,408	0.87	1,145
Company subject to CO_2 tax (0/1)	1.00	2,708	0.84	1,408	0.84	1,145
Company part of CH ETS (0/1)	0.00	2,708	0.02	1,408	0.02	1,145
Company has made formal commitment (0/1)	0.00	2,708	0.08	1,408	0.08	1,145
Panel B: Manager characteristics						
CEO, CFO (0/1)	0.43	23	0.75	1,408	0.76	1,145
Male (0/1)	0.67	21	0.83	1,408	0.86	1,145
Bachelor's degree or higher (0/1)	0.33	21	0.30	1,408	0.31	1,145
Age (years)	56.3	15	53.0	1,394	52.6	1,140
Years at company	16.6	23	17.5	1,387	17.1	1,127
Survey duration (minutes)	–	0	33.2	1,402	36.9	1,142
Total observations	2,708		1,408		1,145	

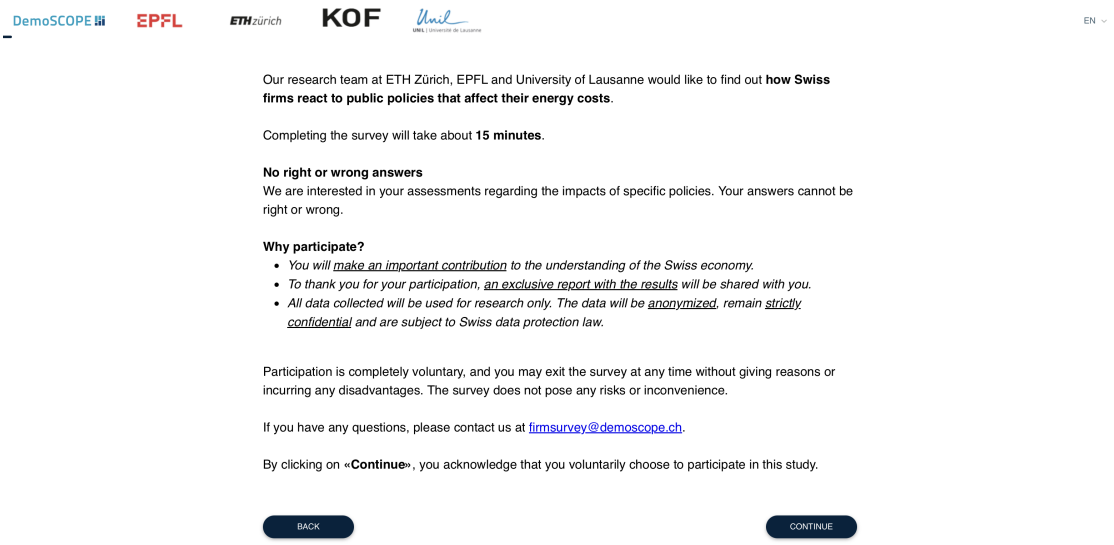
Notes: Entries are means. The N column reports the number of non-missing observations for each variable within each sample. *Incomplete*: respondents who did not finish the survey. *End of Survey*: respondents who reached the end but did not complete all the scenario questions. *Complete*: respondents who reached the end and completed all the scenario questions (analysis sample). For binary (0/1) variables, the mean equals the share.

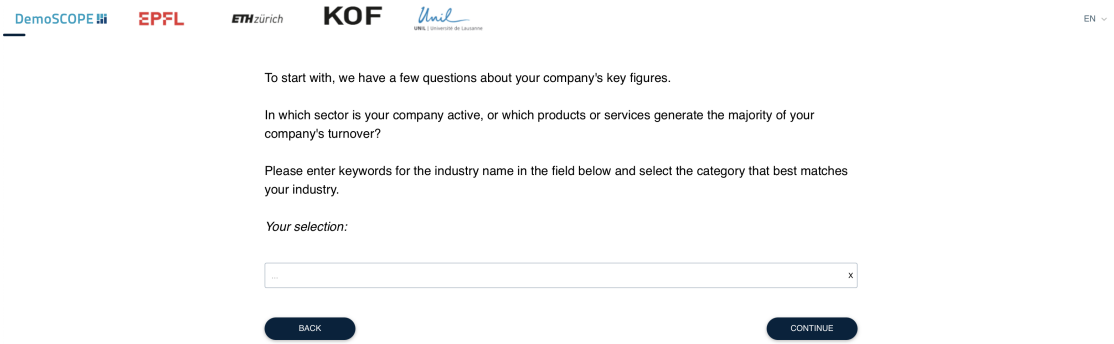
D Additional Summary Statistics and Results

D.1 Attrition and Additional Results

E Questionnaire







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Please provide us with the 4-digit postal code of the production site of your company or business unit.
If your company or business unit has multiple production sites, please provide the main site.

Production can include the manufacture of goods and/or services.

Postal code

BACK CONTINUE

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What was the number of **employees** at your company in Switzerland (converted into full-time equivalents (FTE)) at the end of 2024? Approximate information is sufficient.

FTE

BACK CONTINUE

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What was the **turnover** (excluding VAT) of your company in Switzerland in 2024, including goods/services delivered abroad? Approximate information is sufficient.

CHF

BACK CONTINUE

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What proportion of your total sales was generated **abroad** or **by customers residing abroad in the year** 2024?

0% 100%

BACK CONTINUE

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On the scale below, how would you rate the **intensity of competition** in the sector in which your company operates? Please make a subjective assessment.

very low competition very intense competition

1	2	3	4	5	6	7

Are your main competitors based in Switzerland or abroad?

- ○ All in Switzerland
- ○ Mostly in Switzerland, some abroad
- ○ Roughly half and half
- ○ Mostly abroad, some in Switzerland
- ○ All abroad

BACK CONTINUE

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What were your company's **operating expenditures/expenses** (including employee costs, cost of materials, other operating expenses, depreciation; excluding investments) in Switzerland in the year 2024? Approximate indication is sufficient.

CHF

BACK CONTINUE

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In 2024, what proportion of your total operating expenditures was directly spent on **energy products** such as electricity, oil or gas fuels, motor fuels, industrial, waste, coal, or wood? If you don't know the exact percentage, you can give an approximation.

Please enter a percentage value between 0 and 100%.

% %

BACK CONTINUE

DemoSCOPE EPFL ETH zürich KOF Unil Université de Lausanne EN

Which sources of energy does your company directly use?
Please select all options that apply.

- ☐ Electricity
- ☐ Fossil fuels (natural gas, heating oil, gasoline and diesel, including for motor vehicles)
- ☐ Other energy sources: waste, coal, or wood

BACK CONTINUE

DemoSCOPE EPFL ETH zürich KOF Unil Université de Lausanne EN

Which sources of energy does your company directly use?
Please select all options that apply.

- ☑ Electricity
- ☑ Fossil fuels (natural gas, heating oil, gasoline and diesel, including for motor vehicles)
- ☑ Other energy sources: waste, coal, or wood

BACK CONTINUE

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In 2024, how were your expenditures on energy **split between different types of energy sources:** electricity, fossil fuels (natural gas, heating oil, gasoline and diesel, including for motor vehicles), and other energy sources (waste, coal, or wood)?

Please report the **percentage share of electricity expenditures in your total energy expenditures**. For instance, if one-third of your energy expenditures were associated with electricity, one-third with fossil fuels, and one-third with other energy sources, report a share of 33% for each energy source. It is ok to approximate these percentages if you don't know the exact figure.

Please enter a percentage value between 0 and 100%.

Share of **electricity** expenditures in your total energy expenditures

0% 100%

☐ Fix value

Share of **fossil fuel** expenditures in your total energy expenditures

0% 100%

☐ Fix value

Share of **other energy sources** expenditures in your total energy expenditures

0% 100%

☐ Fix value

BACK CONTINUE

DemoSCOPE EPFL ETH zürich KOF Unil UNIL | Université de Lausanne EN

Which sources of energy does your company directly use?
Please select all options that apply.

- [x] Electricity
- [x] Fossil fuels (natural gas, heating oil, gasoline and diesel, including for motor vehicles)
- [ ] Other energy sources: waste, coal, or wood

BACK CONTINUE

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In 2024, how were your expenditures on energy expenditure **split between electricity and energy sources from fossil fuels** (natural gas, heating oil, gasoline and diesel, including for motor vehicles)?

Please report the **percentage share of electricity expenditures in your total energy expenditures**. For instance, if 50% of your energy expenditures were associated with electricity, report a share of 50%. It is ok to approximate this percentage if you don't know the exact figure.

Please enter a percentage value between 0 and 100%.

Share of **electricity** expenditures in your total energy expenditures

0% 100%

Fix value

Share of **fossil fuel** expenditures in your total energy expenditures

0% 100%

Fix value

BACK CONTINUE

DemoSCOPE EPFL ETH zürich KOF Unil UNIL | Université de Lausanne EN

Which sources of energy does your company directly use?
Please select all options that apply.

- [x] Electricity
- [ ] Fossil fuels (natural gas, heating oil, gasoline and diesel, including for motor vehicles)
- [x] Other energy sources: waste, coal, or wood

BACK CONTINUE

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In 2024, how were your expenditures on energy expenditure **split between electricity and other energy sources** (waste, coal, or wood)?

Please report the **percentage share of electricity expenditures in your total energy expenditures**. For instance, if 50% of your energy expenditures were associated with electricity, report a share of 50%. It is ok to approximate this percentage if you don't know the exact figure.

Please enter a percentage value between 0 and 100%.

Share of **electricity** expenditures in your total energy expenditures

0% 100%

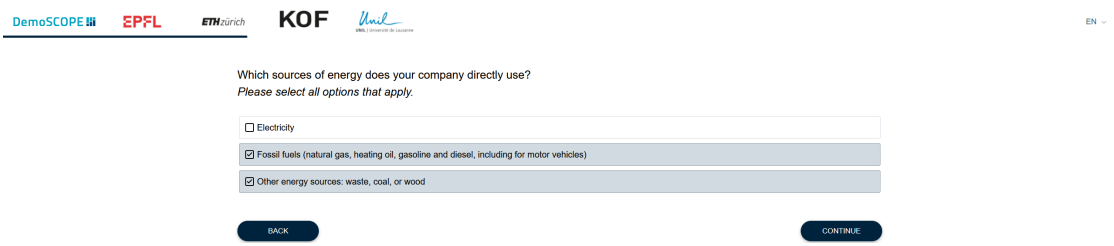
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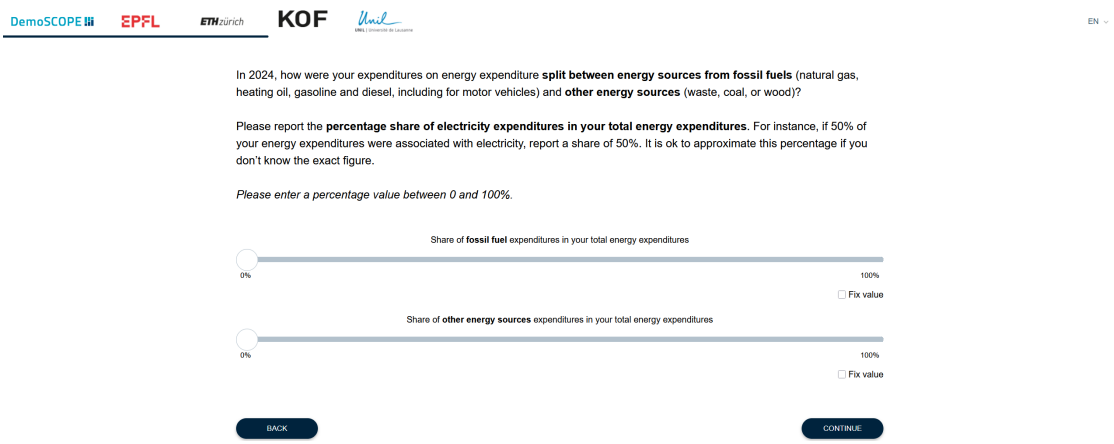
Share of **other energy sources** expenditures in your total energy expenditures

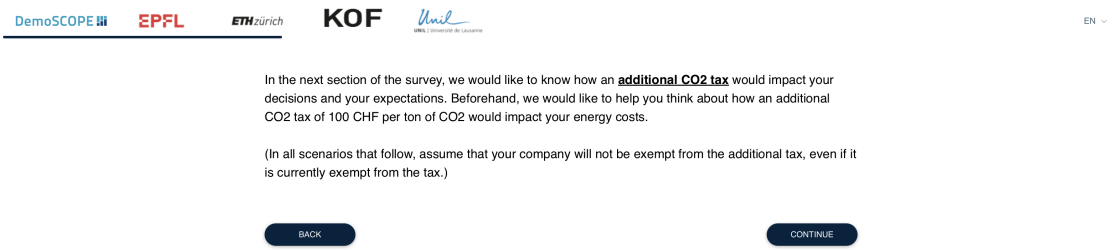
0% 100%

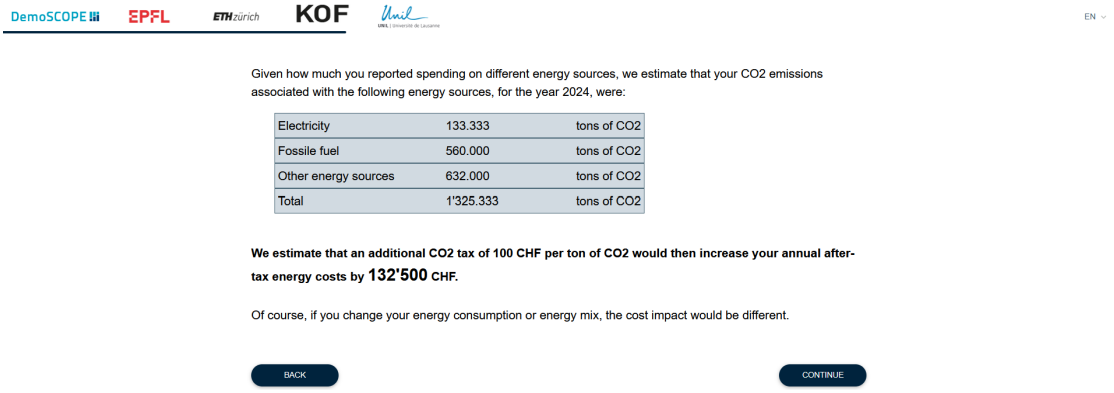
Fix value

BACK CONTINUE









Note: The values shown on the preceding and following pages are illustrative and correspond to reported operating expenditures of CHF 10,000,000, an energy expenditure share of 10%, and energy source shares of 40% electricity, 40% fossil fuels, and 20% other sources. The reproduced pages correspond to the treatment group facing a CO2 tax increase of CHF 100; the alternative treatment group faced a CO2 tax increase of CHF 300.

DemoSCOPE EPFL ETH zürich KOF Unil Université de Lausanne EN

We would now like you to consider the impacts of an **additional CO2 tax of 100 CHF per ton of CO2** for the following three scenarios. As previously stated, we estimate that an additional CO2 tax of 100 CHF per ton of CO2 would then increase your annual after-tax energy costs **by 132'500 CHF**. For all scenarios, consider that the tax would be introduced in 2025.

In Scenario 1, the CO2 tax is levied **on all firms in Switzerland, including your firm**.

In Scenario 2, the CO2 tax is targeted **only at Swiss firms in your sector, including your firm**. All firms outside your sector are not subject to the tax.

In Scenario 3, the CO2 tax is targeted **only on your firm**. All other firms in Switzerland are not subject to the tax. (This third scenario is more hypothetical in nature.)

First, let's consider the impact on **production of services and goods**: In your opinion, for each of the three scenarios described above, how would an additional tax of 100 CHF (per ton of CO2) impact:
(1.) the overall economic production in Switzerland,
(2.) your Swiss competitors' production (in case there are firms located in Switzerland among your competitors),
(3.) your company's production?

BACK CONTINUE

DemoSCOPE EPFL ETH zürich KOF Unil Université de Lausanne EN

We would now like you to consider the impacts of an **additional CO2 tax of 100 CHF per ton of CO2** for the following three scenarios. As previously stated, we estimate that an additional CO2 tax of 100 CHF per ton of CO2 would then increase your annual after-tax energy costs **by 132'500 CHF**. For all scenarios, consider that the tax would be introduced in 2025.

In Scenario 1, the CO2 tax is levied **on all firms in Switzerland, including your firm**.

In Scenario 2, the CO2 tax is targeted **only at Swiss firms in your sector, including your firm**. All firms outside your sector are not subject to the tax.

In Scenario 3, the CO2 tax is targeted **only on your firm**. All other firms in Switzerland are not subject to the tax. (This third scenario is more hypothetical in nature.)

First, let's consider the impact on **production of services and goods**: In your opinion, for each of the three scenarios described above, how would an additional tax of 100 CHF (per ton of CO2) impact:
(1.) the overall economic production in Switzerland,
(2.) your Swiss competitors' production (in case there are firms located in Switzerland among your competitors),
(3.) your company's production?

Please assess: By how many percent will annual **production volume be lower or higher in 2028 (i.e., in the medium run) due to the tax**, compared to a situation in which there is no additional tax?

*Please enter a **negative number** if you believe the tax will reduce production. To give you a point of reference, the worst 3-year decline in Swiss economic production (i.e., in Swiss real GDP) over the last 75 years was -7.3%. Enter a **positive number** if you believe that the tax will increase production.*

Impact on **Switzerland's** volume of produced services and goods (measured at current sales prices):

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Impact on **your competitors'** volume of produced services and/or goods (measured at current sales prices):

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Scenario 2: The 100 CHF CO2 tax is levied on **only on firms in your sector**.

-20% 20%

○ less than -20% ○ more than +20%

Impact on **your firm's** volume of produced services and/or goods (measured at current sales prices):

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Scenario 2: The 100 CHF CO2 tax is levied on **only on firms in your sector**.

-20% 20%

○ less than -20% ○ more than +20%

Scenario 3: The 100 CHF CO2 tax is levied on **only on your firm**.

-20% 20%

○ less than -20% ○ more than +20%

BACK CONTINUE

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As previously stated, we estimate that an additional CO2 tax of 100 CHF per ton of CO2 would then increase your after-tax energy costs **by 132'500 CHF**. Now, let's consider the impact on **prices**:

Please assess: By how many percent will **prices be lower or higher in 2028 (i.e., in the medium run) due to the tax**, compared to a situation in which there is no additional tax?

*Please enter a **positive number** if you believe the tax will increase prices. Enter a **negative number** if you believe that the tax will lead to a decrease in prices.*

Impact on **Switzerland's** prices of produced services and goods:

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Impact on **your competitors'** prices of produced services and/or goods:

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Scenario 2: The 100 CHF CO2 tax is levied on **only on firms in your sector**.

-20% 20%

○ less than -20% ○ more than +20%

Impact on **your firm's** prices of produced services and/or goods:

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Scenario 2: The 100 CHF CO2 tax is levied on **only on firms in your sector**.

-20% 20%

○ less than -20% ○ more than +20%

Scenario 3: The 100 CHF CO2 tax is levied on **only on your firm**.

-20% 20%

○ less than -20% ○ more than +20%

BACK CONTINUE

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As previously stated, we estimate that an additional CO2 tax of 100 CHF per ton of CO2 would then increase your after-tax energy costs **by 132'500 CHF**. You have previously indicated that you estimate that the volume of services and/or goods produced by your company would change by 0% in scenario 1 (the CO2 tax of CHF 100 is levied on all firms in Switzerland).

Finally, let's look at the impact on **energy intensity**, **employment**, and **profits** for scenario 1.

Please assess: By how many percent will **your firm's** (a) energy consumption per unit of good and/or service, (b) number of employees, and (c) profits **be lower or higher in 2028 (i.e., in the medium run) due to the tax**, compared to a situation in which there is no additional tax?

*Please enter a **negative number** if you believe the tax will reduce your energy intensity, number of employees, and profits.*

Impact on **your firm's energy consumption** per unit of goods and/or services:

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Impact on **your firm's number of employees**:

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

Impact on **your firm's profits**:

Scenario 1: The 100 CHF CO2 tax is levied on **all firms in Switzerland**.

-20% 20%

○ less than -20% ○ more than +20%

BACK CONTINUE

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The current carbon tax in Switzerland sets a CO2 price of 120 CHF/ton of CO2 and applies to about ¾ of CO2 emissions in Switzerland.

In your view, what would be the ideal CO2 price if a tax reform were to be implemented such that the current Swiss CO2 tax is replaced by a new CO2 tax that has no exemptions anymore and covers all sectors and CO2 emissions in Switzerland?

Please, consider the point of view of your firm and remember all answers are confidential.

Please indicate the price level in CHF (not the increase compared to today's price).

CHF/ton of CO2

Now, consider that **your firm and competitors, and only your firm and competitors, are exempted from the tax reform.**

What would be the ideal CO2 price under such a reform?

Please, again consider the point of view of your firm and remember all answers are confidential.

Please indicate the price level in CHF (not the increase compared to today's price).

CHF/ton of CO2

BACK CONTINUE

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Relative to other firms in your sector in Switzerland, do you think **your firm** produces fewer or more CO2 emissions per unit volume of services and/or goods produced than other firms?

- ○ Less than the other firms in my sector (lower CO2 intensity)
- ○ Same as the other firms
- ○ More than the other firms in my sector (higher CO2 intensity)
- ○ *I don't know*

BACK CONTINUE

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Relative to all other sectors in Switzerland, do you think that **the firms in your sector** produce more or less CO2 emissions per unit volume of services and/or goods produced than firms in the other sectors?

- ○ Less than the other sectors (lower CO2 intensity)
- ○ Same as the other sectors
- ○ More than the other sectors (higher CO2 intensity)
- ○ *I don't know*

BACK CONTINUE

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We would like to know if your firm is currently subject to a CO2 regulation or exemption.

Is your company exempt from the Swiss CO2 tax?

Yes | No

○ *I don't know*

Does your company take part in the Swiss Emission Trading System (CH EHS/SEQE)?

Yes | No

○ *I don't know*

Has your company made a formal commitment to the Confederation to reduce greenhouse gas emissions?

Yes | No

○ *I don't know*

BACK CONTINUE

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Finally, a few questions about you personally and your assessment of this questionnaire.

How many years have you been working at your current company?

years

BACK CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
UNIL | Université de Lausanne
EN
What position do you hold in the company?
CEO
CFO
Other C-Levels
Senior Management
Junior Management
Other:
BACK
CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
UNIL | Université de Lausanne
EN
How old are you?
Under 25
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70 or older
No answer
BACK
CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
UNIL | Université de Lausanne
EN
What is your gender?
Male
Female
Other
No answer
BACK
CONTINUE

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What is the highest level of education you have completed?

- ○ Compulsory education attended but not completed
- ○ Compulsory education
- ○ 1-year education and training course / bridging course
- ○ Upper-secondary specialised school
- ○ Apprenticeship in enterprise (VET) / basic vocational training / vocational school / commercial school
- ○ Academic baccalaureate / teacher training certificate
- ○ Vocational baccalaureate / specialised baccalaureate
- ○ Federal PET examination with federal PET diploma / higher vocational examination with federal diploma/Master certificate
- ○ College of higher vocational education and training
- ○ Bachelor' degree: university, ETH/EPF, university of applied sciences, university of teacher education (incl. diploma from university of applied sciences/university of teacher education)
- ○ Master's degree: university, ETH/EPF, university of applied sciences, university of teacher education (incl. licentiate, university/ETH/EPF diploma)
- ○ Doctorate, post-doctoral qualification (habilitation)
- ○ *No answer*

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With your participation in the survey you have been supporting our research on the Swiss economy. We would like to conduct further company surveys in the future. To this end, we are planning to set up a panel, for which we are dependent on your support.

May we invite you again for future surveys? If you would like to take part in future surveys (approximately twice a year), you can enter your name and e-mail address below. Once we have this information, we can also send you an exclusive report on the results of the survey. Only survey participants will have access to this report.

If you accept our invitation, you can of course still have your name removed from our e-mail list at any time in the future and decide individually for each survey whether you would like to participate or not.

- ○ Yes, please invite me for future surveys.
- ○ No, do not invite me for future surveys.

BACK CONTINUE

DemoSCOPE EPFL ETH zürich KOF Unil Université de Lausanne EN

With your participation in the survey you have been supporting our research on the Swiss economy. We would like to conduct further company surveys in the future. To this end, we are planning to set up a panel, for which we are dependent on your support.

May we invite you again for future surveys? If you would like to take part in future surveys (approximately twice a year), you can enter your name and e-mail address below. Once we have this information, we can also send you an exclusive report on the results of the survey. Only survey participants will have access to this report.

If you accept our invitation, you can of course still have your name removed from our e-mail list at any time in the future and decide individually for each survey whether you would like to participate or not.

- ◉ Yes, please invite me for future surveys.
- ○ No, do not invite me for future surveys.

After completing the survey, you will receive an e-mail from our service partner DemoSCOPE to confirm your e-mail address.

First name

Surname

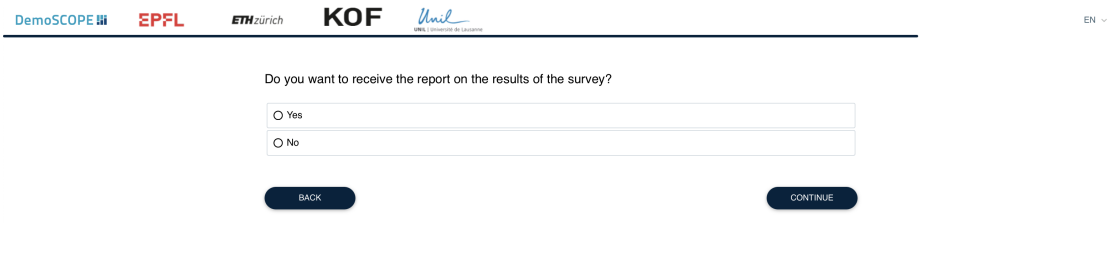
To simplify the invitation process, we would be grateful if you could provide us with an e-mail address to which we can send future invitations to these surveys.

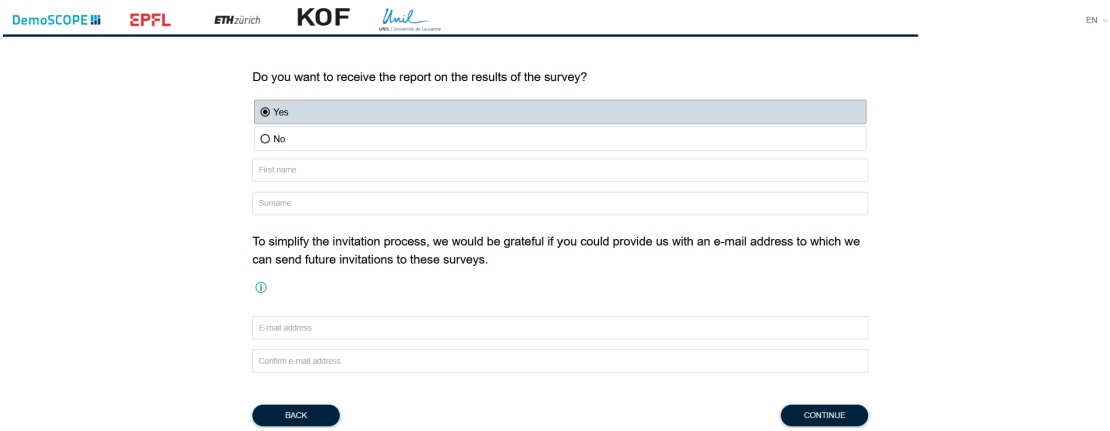
ⓘ

E-mail address

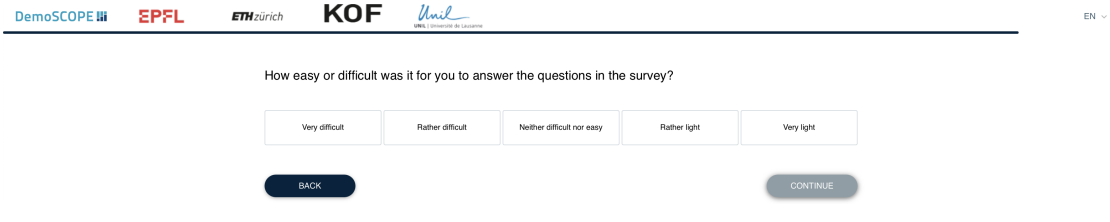
Confirm e-mail address

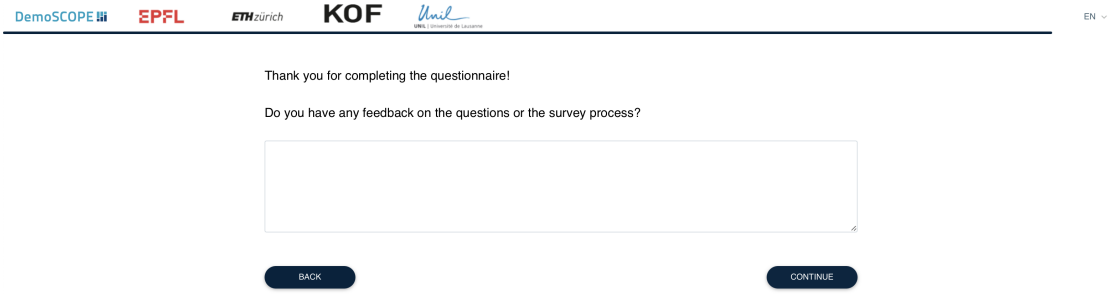
BACK CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
EN
Do you want to receive the report on the results of the survey?
Yes
No
BACK
CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
EN
Do you want to receive the report on the results of the survey?
Yes
No
First name
Surname
To simplify the invitation process, we would be grateful if you could provide us with an e-mail address to which we can send future invitations to these surveys.
E-mail address
Confirm e-mail address
BACK
CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
EN
How interesting or uninteresting did you find the questions in the survey?
Very uninteresting
Rather uninteresting
Neither interesting nor un-interesting
Rather interesting
Very interesting
BACK
CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
EN
How easy or difficult was it for you to answer the questions in the survey?
Very difficult
Rather difficult
Neither difficult nor easy
Rather light
Very light
BACK
CONTINUE


DemoSCOPE
EPFL
ETH zürich
KOF
Unil
EN
Thank you for completing the questionnaire!
Do you have any feedback on the questions or the survey process?
BACK
CONTINUE

F Calculation of Carbon Tax Cost

G Firm Population and Survey Sample

G.1 Firm Population

Our firm survey covers the entire Swiss economy, with the exception of (i) the Italian- and Romansh-speaking regions, and (ii) sectors outside the market economy—specifically, Sectors O (Public Administration and Defence; Compulsory Social Security), P (Education), T (Activities of Households as Employers; Undifferentiated Goods- and Services-Producing Activities of Households for Own Use), and U (Activities of Extraterritorial Organisations and Bodies).

Table 10 presents company population numbers from the Business and Enterprise Register (BER) maintained by the Swiss Federal Statistical Office, disaggregated by employee size class and economic sector, according to letter codes in the Swiss General Classification of Economic Activities (NOGA). The NOGA classification corresponds to the Statistical Classification of Economic Activities (NACE) used in the European Community.[11]

G.2 Address Sampling

We construct our company survey sample from three sources: the Orbis company database (Moody's Analytics, 2025), the firm panel maintained by the KOF Swiss Economic Institute at ETH Zurich (KOF Institute, 2025), and an address panel obtained from a survey conducted by us in the year 2023 (Benhima et al., 2024). All three sources are used exclusively to obtain contact e-mail addresses for firms, stratified by sector and company size.[12] The three address panels are presented in the following sections.

[11] Companies located in the Italian- and Romansh-speaking regions account for only 6% of all companies in the BER.

[12] Other firm-level information included in these sources is not used in our analysis. To ensure consistency, all relevant company information is collected directly through the survey.

Table 10: Active Companies (French- and German-speaking Switzerland)

	A	B	C	D	E	F	G	H	I
Micro (1–9)	49163	112	29682	563	1163	39266	59557	10732	21109
	(8.38%)	(0.02%)	(5.06%)	(0.10%)	(0.20%)	(6.70%)	(10.16%)	(1.83%)	(3.60%)
Small (10–49)	1003	94	6491	150	315	6385	7558	1520	4919
	(0.17%)	(0.02%)	(1.11%)	(0.03%)	(0.05%)	(1.09%)	(1.29%)	(0.26%)	(0.84%)
Medium (50–249)	65	15	1822	69	72	793	1051	395	498
	(0.01%)	(0.00%)	(0.31%)	(0.01%)	(0.01%)	(0.14%)	(0.18%)	(0.07%)	(0.08%)
Large (250+)	2	2	381	34	5	84	202	119	62
	(0.00%)	(0.00%)	(0.06%)	(0.01%)	(0.00%)	(0.01%)	(0.03%)	(0.02%)	(0.01%)
Total	50233	223	38376	816	1555	46528	68368	12766	26588
	(8.57%)	(0.04%)	(6.54%)	(0.14%)	(0.27%)	(7.93%)	(11.66%)	(2.18%)	(4.53%)

	J	K	L	M	N	Q	R	S	Total
Micro (1–9)	23543	14527	18873	95054	21455	65682	23899	50259	524639
	(4.01%)	(2.48%)	(3.22%)	(16.21%)	(3.66%)	(11.20%)	(4.08%)	(8.57%)	(89.46%)
Small (10–49)	2179	1581	976	5935	2685	4919	1346	2560	50616
	(0.37%)	(0.27%)	(0.17%)	(1.01%)	(0.46%)	(0.84%)	(0.23%)	(0.44%)	(8.63%)
Medium (50–249)	450	399	117	730	731	1657	194	325	9383
	(0.08%)	(0.07%)	(0.02%)	(0.12%)	(0.12%)	(0.28%)	(0.03%)	(0.06%)	(1.60%)
Large (250+)	73	114	10	109	152	419	32	29	1829
	(0.01%)	(0.02%)	(0.00%)	(0.02%)	(0.03%)	(0.07%)	(0.01%)	(0.00%)	(0.31%)
Total	26245	16621	19976	101828	25023	72677	25471	53173	586467
	(4.48%)	(2.83%)	(3.41%)	(17.36%)	(4.27%)	(12.39%)	(4.34%)	(9.07%)	(100.00%)

Note: The table displays the number of active companies and their percentage shares (in parentheses) in the German- and French-speaking regions of Switzerland, disaggregated by NOGA letter sector and employee size class, as recorded in the Business and Enterprise Register of the Swiss Federal Statistical Office. Sectors O, P, T, and U are excluded. Shares are relative to the grand total of 586,467 companies.

G.3 Orbis Address Panel

The Orbis database provides one of the most comprehensive collections of firm-level contact e-mails in Switzerland. We draw our address sample from Orbis using stratified sampling, based on the population benchmarks shown in Table 10.

Rather than applying purely proportional stratified sampling, we intentionally oversample larger firms and selected sectors. Regards sector oversampling: for each company size stratum in Sectors C (Manufacturing), D (Energy Supply), E (Water Supply; Sewerage; Waste Management and Remediation), F (Construction), G (Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles), and H (Transportation and Storage), the number of contact e-mails is doubled relative to the values in Table 10. With regard to oversampling of larger firms: in order to achieve the target distribution across firm size categories in the unified address panel (see Section G.6), and taking into account the availability of companies in the other two panels (see Sections G.4 and G.5), we needed to sample from the Orbis address database 16,129 micro companies (66.9% of all sampled Orbis companies, as compared to micro companies accounting for 89.5% of all companies in the population), 3,700 small companies (15.4% vs. 8.6%), 2,407 medium-sized companies (10.0% vs. 1.6%), and 1,838 large companies (7.7% vs. 0.3%).

The rationale behind the oversampling strategy is as follows: A larger number of observation units is allocated to those strata of the company population that contribute more heavily to the overall aggregation, either due to their high number of employees or high value added. As a result, these strata, which are important for the aggregate, are more accurately captured, reducing the expected sampling error, i.e., the deviation of the survey aggregates from the unobserved population aggregate, which would have been obtained had the entire population been surveyed. Furthermore, the decision to oversample the Sectors C to H is motivated by the expectation that these sectors are more likely to exhibit pronounced effects in response to the climate shock scenario, along with higher within-stratum variability among firms, relative to other sectors. For other sectors, by contrast, we anticipate the effects to be rather small or even zero, and the cross-company variance to be relatively low. Since higher variance implies a larger expected sampling error, ceteris paribus, it justifies a proportionally larger sample size for these

high-variance cells. Notably, during the aggregation of survey results, the over- and undersampling is corrected by reweighting firms according to population statistics.

G.4 KOF Address Panel

The KOF Business Tendency Surveys are conducted monthly or quarterly among Swiss firms across a broad range of sectors (KOF Institute, 2025). For our study, KOF kindly provided access to the address panel underlying the following sectoral surveys: manufacturing, construction, general services, wholesale services, banking, financial, and insurance services, and project engineering services. Table 11 presents the number of companies in this address panel, disaggregated by firm size and sector.

Table 11: KOF Gross Sample

	C	F	G	H	J	K	L	M	N	Q	R	S	Total
Micro (0–9)	138 (4.36%)	180 (5.69%)	106 (3.35%)	25 (0.79%)	86 (2.72%)	51 (1.61%)	31 (0.98%)	194 (6.13%)	42 (1.33%)	51 (1.61%)	31 (0.98%)	12 (0.38%)	947 (29.93%)
Small (10–49)	368 (11.63%)	380 (12.01%)	144 (4.55%)	31 (0.98%)	75 (2.37%)	73 (2.31%)	31 (0.98%)	194 (6.13%)	48 (1.52%)	53 (1.68%)	18 (0.57%)	13 (0.41%)	1428 (45.13%)
Medium (50–249)	204 (6.45%)	129 (4.08%)	73 (2.31%)	26 (0.82%)	32 (1.01%)	39 (1.23%)	10 (0.32%)	40 (1.26%)	22 (0.70%)	59 (1.86%)	6 (0.19%)	6 (0.19%)	646 (20.42%)
Large (250+)	58 (1.83%)	18 (0.57%)	6 (0.19%)	8 (0.25%)	8 (0.25%)	11 (0.35%)	1 (0.03%)	8 (0.25%)	6 (0.19%)	17 (0.54%)	1 (0.03%)	1 (0.03%)	143 (4.52%)
Total	768 (24.27%)	707 (22.35%)	329 (10.40%)	90 (2.84%)	201 (6.35%)	174 (5.50%)	73 (2.31%)	436 (13.78%)	118 (3.73%)	180 (5.69%)	56 (1.77%)	32 (1.01%)	3164 (100.00%)

Note: The table presents the number of company contacts in the KOF address panel available for our survey, along with their corresponding percentage shares (in parentheses), disaggregated by NOGA sector letter and firm size class. Shares are calculated relative to the total sample of 3,164 firms.

G.5 Address Panel from 2023 Survey

Between June and August 2023, we conducted a survey on energy prices and firm decision-making among Swiss firms (Benhima et al., 2024). The survey sample was drawn from the BER using stratified random sampling based on the size-

sector distribution of the BER firm population. Firms were randomly selected within each stratum to ensure representative coverage. A total of 353 respondents registered for future survey participation. In line with the criteria outlined in Section G.1, we exclude Italian-speaking respondents and respondents from Sectors O, P, T, and U. Further, we exclude certain legal types: cooperatives, clubs, foundations, public-law institutions, public corporation (administration), public corporation (enterprise). Table 12 presents the size-sector distribution of the remaining 276 contacts.

G.6 Total Gross Sample

The total gross sample, comprising the combined address panels, includes approximately 26,900 companies. In addition, we contacted 100 companies known to participate in the Swiss Emissions Trading System (ETS). The overall sample size of approximately 27,000 was determined by the sending capacity of the KOF survey e-mail distribution system, which permits 9,000 e-mails per day (i.e., 10,000 minus 1,000 reserved for other communications), and by our objective to complete distribution within three days.

Of the total gross sample, 16,900 are micro-enterprises (62.8%), 5,000 are small enterprises (18.6%), 3,000 are medium-sized enterprises (11.2%), and 2,000 are large enterprises (7.4%). These figures were determined a priori to ensure the oversampling of companies larger than micro-enterprises (see Section G.3).

Table 12: 2023 Survey Gross Sample

	C	D	E	F	G	H	I	J
Micro (1–9)	6 (2.17%)	1 (0.36%)	1 (0.36%)	14 (5.07%)	22 (7.97%)	3 (1.09%)	4 (1.45%)	10 (3.62%)
Small (10–49)	20 (7.25%)	0 (0.00%)	0 (0.00%)	13 (4.71%)	17 (6.16%)	5 (1.81%)	4 (1.45%)	9 (3.26%)
Medium (50–249)	10 (3.62%)	1 (0.36%)	0 (0.00%)	7 (2.54%)	4 (1.45%)	0 (0.00%)	1 (0.36%)	1 (0.36%)
Large (250+)	10 (3.62%)	2 (0.72%)	0 (0.00%)	2 (0.72%)	2 (0.72%)	0 (0.00%)	0 (0.00%)	1 (0.36%)
Total	46 (16.67%)	4 (1.45%)	1 (0.36%)	36 (13.04%)	45 (16.30%)	8 (2.90%)	9 (3.26%)	21 (7.61%)

	K	L	M	N	Q	S	R	Total
Micro (1–9)	7 (2.54%)	4 (1.45%)	28 (10.14%)	6 (2.17%)	9 (3.26%)	3 (1.09%)	0 (0.00%)	118 (42.75%)
Small (10–49)	5 (1.81%)	0 (0.00%)	20 (7.25%)	3 (1.09%)	3 (1.09%)	1 (0.36%)	0 (0.00%)	100 (36.23%)
Medium (50–249)	1 (0.36%)	0 (0.00%)	3 (1.09%)	2 (0.72%)	2 (0.72%)	0 (0.00%)	1 (0.36%)	32 (11.59%)
Large (250+)	1 (0.36%)	1 (0.36%)	1 (0.36%)	2 (0.72%)	4 (1.45%)	0 (0.00%)	0 (0.00%)	26 (9.42%)
Total	14 (5.07%)	5 (1.81%)	52 (18.84%)	13 (4.71%)	18 (6.52%)	4 (1.45%)	1 (0.36%)	276 (100.00%)

Note: The table presents the number of company contacts available from a previous survey, along with their corresponding percentage shares (in parentheses), disaggregated by NOGA sector letter and firm size class. Shares are calculated relative to the total sample of 276 firms.