Supply Chain Networks and the Macroeconomic Expectations of Firms*

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Abstract: We explore the role of supply chain networks in shaping macroeconomic expectations. Using a randomized control trial of over 1,000 firm-firm pairs in New Zealand that have a business relationship, we provide an information treatment to analyze both the direct effects on expectations and action of firms receiving this information and the *network effect* on connected firms that did not directly receive information. In a follow-up three months later, we find that the treatment significantly affects the expectations of both directly treated and connected firms. Using the variation induced by the treatment, we find that an increase in expected GDP growth increases prices and employment decisions. Moreover, an increase in expected GDP uncertainty reduces treated and connected firms' price, investment, and employment decisions. Our empirical evidence and insights from a production network model show that communication, not only actions, drives the change in expectations and actions of connected firms. Consequently, communication between firms connected through the supply chain is a relevant transmission mechanism of shocks and aggregate uncertainty.

Keywords: Firms, Macroeconomic Expectations, Networks, Spillovers

JEL codes: D8, E3, E4, E5, L14

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1 Introduction

Macroeconomic expectations are a key driver of aggregate fluctuations (Beaudry and Portier, 2007; Angeletos and La'o, 2013). Recent studies have focused on exploring how firms form expectations about the aggregate economy (Coibion et al., 2018) and how those expectations affect their decisions (Werning, 2022; Coibion et al., 2020b). Additionally, there is an increased interest in studying how aggregate and expected uncertainty affect firms' decisions (Bloom et al., 2007; Kumar et al., 2023).

While recent literature has advanced our understanding of how firms form expectations and act upon them, there is less focus on the role of firm networks in the expectation formation process and how communication between firms affects their decisions. In this paper, we investigate *how supply chain network of firms affect their macroeconomic expectations and actions*.

Specifically, this paper leverages data from over 1,000 firm-firm pairs in New Zealand with established business relationships. We design a randomized controlled trial (RCT), assigning one-third of the firm pairs to a control group and the remaining pairs to one of two information-based treatment conditions: information about the first moment of next year's GDP growth (Treatment 1), and information about the second moment of next year's GDP growth (Treatment 2). In each treated pair, only one randomly selected firm (either a supplier or a customer of the connected firm) receives the information. This allows us to assess the *direct effects* of receiving macroeconomic information for the main (treated) firm and the *indirect effects* on the connected/linked firm. We conduct a two-period survey (baseline and endline), and information is provided at the end of the baseline survey. The endline survey takes place 3 months later, allowing us to identify the diffusion of macroeconomic information between a firm and its supplier or customer.

We find that providing information about future GDP growth and uncertainty instantaneously changes the expectations of directly treated firms.[1] We follow up with directly

[1] We also show that, as expected in the baseline survey, there is no effect on the expectations of connected firms because there is no possibility of diffusion at that stage.

treated firms and find similar effects on their expectations after three months, showing persistent effects of our information treatment. More importantly, we also follow up with connected firms and find that firms linked to the treated firms through input-output linkages significantly change their mean and uncertainty expectations to a similar magnitude as those directly treated firms.

We then explore firms' actions. We use the variation coming for the treatment to measure the causal effect of an increase in GDP expectations and expected GDP uncertainty on various decisions of the firm for both directly treated and connected firms. We find that a one percentage point increase in expected GDP growth increases firms' prices by 0.29 percentage points and employment by 0.89 percentage points, compared to their plan three months ago. Additionally, we find that a one percentage point increase in uncertainty, measured as the distance between the most and least likely GDP growth scenario, decreases prices (-0.37 percentage points), investment (-0.81 percentage points), and employment (-0.83 percentage points), compared to their plans 3 months ago. We find no effect on wages for both mean and uncertainty forecast-based treatments.

We then separate the sample between directly treated and connected firm. Our novel result is that we find no substantial differences in actions between directly treated and connected firms. Although connected firms do not directly receive the information, their actions align as if they had, suggesting meaningful interaction and information spillovers within firm networks.

In the endline survey and after the questions about expectations, we include questions related to the intensity and content of the communication. Using these questions, we then explore whether communications or actions can explain the effect that we find. We find that firms communicate often with each other about product decisions and industry trends but less frequently about the aggregate economy. We find that the treatment increased the amount of communication about the specific information we provided, that is, GDP forecasts. This result indicates that the treatment increased the intensity of the communication about the information we gave them, but as firms were already talking to each other about other topics, we did not meaningfully change the frequency of commu-

nication that firms had.

We then show that the effects we found do not depend on the type of relationship, whether they are customer or suppliers, or on the expenditure/sales share. As cost or supply shocks by itself should be proportional to the intensity of the business relationship, these findings suggest that the reaction is related to additional information that the firm is getting, given the change in expectation we found.

We finally, estimate the relationship between the own firm's posterior forecast and uncertainty, using the IV exercise, but controlling for the actions of the treated firm. This exercise allows us to explicitly control for actions, such as price, investment, employment and wages. We find that our main estimate are not affecting by this actions, again suggesting that the change in expectations and action of the connected firm is produced, at least in part, by the communication that the firm had, and not only the actions of the other firm.

We incorporate a communication network into a production network model to examine its role in firms' expectation formation and pricing decisions, as well as its macroeconomic implications. Specifically, we build on the sector-level Phillips curve framework of Rubbo (2023) and assume that, due to imperfect information about the deterministic component of output growth, firms are ambiguity-averse similar in spirit to Ilut and Schneider (2014).[2] Aversion to ambiguity makes information exchange valuable, and communication about output growth becomes central to the expectation formation process. This setup allows us to show that, in equilibrium, firms form expectations not only based on their own information set but also the information set of other firms through communication networks. Consequently, firms' pricing decisions are influenced by both the production and communication networks.

Our quantitative application demonstrates that in the absence of communication, there would be substantial asymmetry in firms' expectations and actions. However, when

[2]Ambiguity-aversion refers to Knightian uncertainty whereby firms cannot assess the probability distribution of outcomes accurately. See Epstein and Wang (1994) for an early application of such uncertainty to asset pricing and Ilut and Schneider (2023) for a recent review.

the communication network is active, and information treatment is given, upstream and downstream firms converge, leading to more symmetric expectations and decisions. This aligns with our empirical findings, which show that treatment effects are similar regardless of whether the connected firms are upstream or downstream relative to the treated firms.

Our analysis indicates that communication among firms is a crucial yet previously unexplored mechanism that can explain the effects we find. In light of our results, we introduce communication as an additional transmission mechanism of shocks through which firm-specific idiosyncratic shocks propagate and lead to important macroeconomic implications. We show that communication can amplify macroeconomic volatility, especially when shocks originate from downstream firms. Considering our results and model analysis, we also argue that failing to appropriately control for firms' expectations when the production network interacts with the communication network can lead one to conclude that the Phillips curve is steeper than it is. Finally, the finding that information spreads through the production network can help policymakers design more effective policies to mitigate economic volatility from shocks to expectations.

This paper adds to the literature that has been trying to understand the role of firms' inflation expectations and how they affect firms' decisions (Coibion et al., 2020a). Coibion et al. (2018), Coibion et al. (2020b) and Abberger et al. (2024) show how changes in firms' expectations, usually about inflation, change firms decisions in various outcomes. These works focus on the direct effect of expectations on firms' decisions.

However, firms do not operate or form expectations in isolation (Bramoullé et al., 2016) and the COVID-19 supply chain disruptions (Bonadio et al., 2021; Ascari et al., 2024; Di Giovanni et al., 2022) further underscored the inherently interconnected nature of firms and the role of input-output linkages in shock propagation (Gabaix, 2011; Acemoglu et al., 2012).[3] This paper adds to the literature that focuses on the expectation formation process

[3]Gabaix (2011) shows that the classical Lucas (1995) framework, which assumes that idiosyncratic shocks cancel out in aggregate due to the law of large numbers, does not necessarily hold in the data. Complementing this, Acemoglu et al. (2012) demonstrates that idiosyncratic shocks can have aggregate consequences under network structures, even when the law of large numbers assumption is maintained.

of firms by studying the network effect, through communication between firms.

Other works have focused on the role of uncertainty in firms' decisions. Bloom et al. (2007) show that higher aggregate uncertainty affects firms' decisions. Kumar et al. (2023) show that uncertainty about aggregate outcomes influences firms' decisions in several outcomes. This paper shows that input-output networks play a role, as firms also communicate uncertainty. Our findings show that uncertainty can be transmitted through these production networks and amplify their direct effects.

There is also literature that studies how individuals form expectations using their social network. Bailey et al. (2018) show that individuals form beliefs about the housing market using their social connections, affecting their decisions. Garcia-Lembergman et al. (2024) show that consumers' inflation expectations are influenced by their social network and explore the macroeconomic implications of those connections. Similarly, in this paper, we show that in the case of firms, input-output networks are relevant for the expectation formation process, not only affecting their expectations but also their expected uncertainty and their decisions.

In that sense, this paper adds to the extensive literature on the role of input-output networks for the transmission of idiosyncratic shocks and their aggregate implications (Gabaix, 2011; Acemoglu et al., 2012). Rubbo (2023) and Pasten et al. (2020) study the effect of these networks on monetary policy, highlighting the challenges for monetary authorities. In this paper, we show another transmission mechanism with significant policy implications, as not only actions but communication can help prevent the transmission of changes in expectations through the network.

The rest of the paper is organized as follows. Section 2 discusses the experimental design and data. Section 3 discusses the estimation strategy and shows how the treatment affects the belief of treated and connected firms. Section 4 outlines the estimation strategy that uses the treatment variation to estimate how the information treatment affects firms' actions and shows the corresponding results. Section 5 presents suggestive evidence for the communication channel. Section 6 analyzes the role of communication for firms' pricing decisions through the lens of a production network model. Finally, Section

7 concludes.

2 Survey and Experimental Design

We administered a two-wave survey where participants were managers of firms. The survey was conducted in a similar design to Kumar et al. (2023). The firms in the survey are characterized in pairs through their supply chain relationship, i.e., a customer firm and their main supplier. The survey was conducted by New Zealand Market Research and Surveys Limited, a survey company that holds basic information about businesses' supply chain relationships. The firm-firm pairs in the survey are primarily from the manufacturing and trade sectors. The firms in the survey employ at least three workers, and their annual sales turnover is at least NZL $ 30,000.

The survey company holds contact details for approximately 8100 pairs of firms. Upon contacting all of them, 1074 pairs agreed to participate in the survey. This is equivalent to a 13 percent response rate. The survey was conducted mainly by telephone. Only around 15 percent participated via an online platform. The first stage included the recruitment of participants. The survey ensured that the pairs were interviewed on similar timelines, i.e., approximately within three days of each other's interview, to avoid participant interaction within the time of the first survey. During the interview, the data research assistants asked questions from the questionnaire, and the responses were recorded using the hardcopy questionnaire. The hard-copy responses were then digitized. Different groups of Data Research Assistants were employed to perform specific tasks to maintain the quality of the survey.

Using our firm-firm pairs, we randomly assigned the sample into three groups.[4] The first group receives information about the first moment of GDP forecast (average GDP

[4]At the time of randomization, the only available firm-level characteristic was firm size, measured by employment. Using this information, we randomly assigned the first firm in each firm-firm pair into one of three groups. We verify in the data that control firms have an average of 31.7 employees, while the two treated groups have 34.5 and 33.4 employees, respectively. Notably, there are no statistically significant differences in firm size across these groups, confirming that randomization was successful based on firm employment.

in year 2025). We call this Treatment 1. In contrast, the second group receives information about the second moment of GDP forecast (uncertainty around GDP forecast for year 2025). We call this Treatment 2. The last group receives no information, i.e., the control group. Within each treated group, we further randomized whether the firm receives direct (main firm) or indirect information (linked firm). For the later group, we call those firms as untargetted treated firms because of their proximity to firms that receive direct information. By doing this, we are able to create 4 sub-groups for the treated sample: (1) Treatment 1 given to customer firms; (2) Treatment 1 given to supplier firms; (3) Treatment 2 given to customer firms; (4) Treatment 2 given to supplier firms.

We conduct the study in two time periods. The first wave was implemented between July to October 2024 and the followup wave was conducted between October 2024 to January 2025. The first is a baseline survey, during which the treated firms receive the information at the end. We then return to these firms after three months, allowing sufficient time for the information to be disseminated.

2.1 Intervention

Our intervention has two treatment arms and one control arm.

1. Treatment 1 (Mean Treatment): The information provided in this arm is about the first moment of GDP forecast i.e., the first moment of future economic growth. The text provided to the directly treated firms is:
   We are going to give you information from a group of leading experts about the New Zealand economy. According to Consensus Economics, a leading professional forecaster, the average prediction among professional forecasters is that the real GDP will grow by 2.3% in 2025.

2. Treatment 2 (Uncertainty Treatment): The information provided in this arm is about the second moment of GDP forecast, i.e., the second moment of future economic growth. The text provided to the directly treated firms is:
   We are going to give you information from a group of leading experts about the New Zealand economy. According to Consensus Economics, a leading professional forecaster, the difference

between the lowest and highest predictions of real GDP growth is 2.2 percentage points for 2025.

3. Control: No information is provided in this arm.

2.2 Data & Randomization

A key information in the dataset includes each firm's Industrial Classification Code (e.g., manufacturing, service) and whether they act as a supplier or customer to other firms in the sample. To maintain unique relationships, we restrict $Firm_i - Firm_u$ pairs to ensure each firm is linked exclusively to one other firm in the sample.

In our RCT process, we randomly assign 300-400 pairs for each group, i.e., treatment 1, treatment 2 and the control group. See Table 1 columns (1)-(2) for the sample we use to estimate the direct effect in Treatment 1 and Treatment 2 (red rectangle). We conducted further randomizations within the treatment groups. To this end, we randomly allocate 150-200 pairs where supplier firms receive direct information (sub-group denoted by $J = 1$ for treatment 1 or $J = 3$ for treatment 2), and we allocate 150-200 pairs where customer firms receive direct information (sub-group denoted by $J = 2$ for treatment 1 and $J = 4$ for treatment 2).

For the network effect, we restrict the analysis to the sample depicted in columns (3)-(4) in Table 1, where only untargeted linked firms data will be used for the analysis (blue rectangle). These are firms that are connected to the main firms but do not directly receive any treatment.

The pairs in the control group are organized similarly to treatment groups. There are main and linked firms and both the group of firms include customer firms and supplier firms in similar compositions to the treatment groups. However, there is no discernible difference between the main and linked firms in the control group since no information is provided to them. Consequently, the only distinction that matters for our analysis is that one firm is a supplier and the other is the customer in the firm-firm pair. Depending on the specific analysis and where we aim to increase statistical power, we may expand

the control sample by utilizing the full dataset, disregarding the main and linked categorizations while retaining supplier and customer categorization. Section B in the appendix show the power calculation.

Table 1: Treatment and Control Groups

	1	2	3	4
Pairs	Main		Linked	
$Firm_i Firm_u$	$Firm_i$	$Firm_i$	$Firm_u$	$Firm_u$
Treatment 1	Supplier $J=1$	Customer $J=2$	Customer $J=1$	Supplier $J=2$
Treatment 2	Supplier $J=3$	Customer $J=4$	Customer $J=3$	Supplier $J=4$
Control	Supplier	Customer	Customer	Supplier

Baseline Data: Our first stage data comes from the main survey. We augment the information on firm-firm pairs with survey questions relating to the age of the firm, number of workers employed, the share of total revenue allocated between labor and other non-labor input costs, current market share, frequency of price change, price and quantity contracts as well as manager's own experience at the firm and their level of education. We also collect the prior belief of manager's expectation of average GDP growth and uncertainty around the growth. Firms in the treatment groups are provided with the treatment information at the end of the survey and they are asked again about their expectations of GDP growth. The control group of firms receives no new information but they are also asked about their beliefs of GDP growth at the end of the survey.

Endline Data: We return to these managers approximately after 3 months to conduct the followup survey. The endline data from the followup survey skips on questions that would be time invariant or easy to infer from the baseline data (such as age of the firm, manager's characteristics) but instead asks time varying questions such as their macroeconomic expectations, their reason behind their expectations (whether these are related to supply chain thinking or not), changes in their prices, investment, employment and wages

since last 3 months, the status of their pricing and quantity contracts with connected firms, the frequency of communication with other firms, the value associated with information acquired along the supply chain, and what would motivate the firms to communicate with their suppliers or customers.

Our main variable of interest in the followup survey is the average GDP expectations one year ahead and the expected uncertainty. Section B.1 shows the direct questions. We measure uncertainty by measuring the difference between the higher and lower expected GDP growth of an individual manager. In the followup survey, we also have important variables indicating firm's recent actions. In particular, in the baseline survey, we ask managers about their plans in terms of price change, investment, employment, and wage growth. In the follow-up survey, we ask for the changes in price, investment, employment, and wages over the last three months.

2.3 Summary of the Structure of the Experiment

We start with the baseline survey. After eliciting firms' characteristics, we survey their prior average future real GDP growth forecast and range around that forecast:

"'*What do you think will be the annual growth rate of real GDP in New Zealand in twelve months? % per year*"

"*Could you provide us with an approximate range of what you think annualized real GDP growth in New Zealand will be over the next 12 months? Between % per year (lowest forecast) and % per year (highest forecast).* "

After collecting prior beliefs, we ask firms to report their plans regarding changes in prices, investment, employment, and average wages over the next three months as percentage changes relative to the current level. At this stage, we randomly assign firms to treatment and control groups. After the information intervention is performed on the treatment groups, we conclude the baseline survey with eliciting all firms' posterior expectations about GDP growth:

"Please let me know what you perceive as the most pessimistic, the most likely, and most optimistic

real GDP growth rate for New Zealand over the next 12 months. What do you think the lowest annualized real GDP growth rate might be for this time period, what do you think the most likely might be, and what do you think the highest might be?"[5]

In the follow-up survey, we initially ask firms about their last price change. Then, we elicit their real GDP growth expectations using the same posterior question in the baseline survey. Finally, we ask firms about their other actions as well as characteristics, including the intensity and characteristics of communication between them and their supplier/customer. For more details we refer the reader to Appendix B.1 where we provide the complete questionnaire.

3 Treatment Effect on Expectations

We start by evaluating whether the treatments affected firms' GDP expectations. To do so, we compare how treated and control firms changed their posterior GDP expectations relative to their prior GDP expectations. We run the following regression to evaluate the treatment effect.

$$Posterior_i^{mean} = \alpha + \beta Prior_i^{mean} + \sum_{j=1}^{2} \gamma^j T_{i,j} + \sum_{j=1}^{2} \theta^j Prior_i^{mean} \times T_{i,j} + \varepsilon_{i,t}, \qquad (1)$$

where $Prior_i^{mean}$ is the forecast about GDP that the firm manager i made before receiving the information treatment in the baseline period t_0. $Posterior_i^{mean}$ is the forecast she made after receiving the treatment. We use two measures of posterior GDP expectations. The first is an instantaneous measure, asked immediately after the information is provided in the baseline, and the second is a persistent measure, asked in the endline three months after the baseline. $T_{i,j}$ is a dummy that takes a value of 1 if the manager i received the treatment j or 0 otherwise.

[5] We ask them to give us a numerical answer for each scenario.

Equation 1 allows us to measure the treatment effect on expectations. The main idea is the following. β represents the correlation between prior and posterior for the control group. As the control received no information, we expect that β is positive and close to 1. Then, $\beta + \theta^j$ estimates the correlation between prior and posterior for the treated group j. If treatment j is effective, we will see changes in expectations such that treated firms place some positive weight on the new information. Consequently, θ^j will be negative, meaning that the slope for the correlation between the prior and posterior is lower than the one for the control group. Because we randomized the treatment, the only difference between the treated and control groups is that the treated firms received information, whereas the control firms did not. Therefore, we can interpret the impact of information on posterior expectations as causal. In other words, θ^j measures the treatment effect on expectations of the treated firms relative to the control firms.

The coefficient γ^j shows the projection to the y-axis of the new relationship between prior and posterior for the treated group. As expectations are generally positive, and the treated group is expected to have a lower correlation between prior and posterior than the control group, we expect γ^j to be positive. Importantly, this method allows us to measure the effectiveness of the treatment, even with zero average treatment effects, as the average expectations might not change, but respondents might move to the same average. This equation is widely used in this type of setting (see for, e.g., Coibion et al., 2018; Kumar et al., 2023).

We present the results in Table 2. Column (1) shows the treatment effect in the baseline period for the firm that was directly treated. Column (2) shows the impact for the firms connected to the treated firms but did not receive any information. Column (3) shows the effect on the treated firm in the follow-up period, and Column (4) shows the impact on the connected firm in the follow-up period.

Table 2: Treatment Effect on GDP Expectations in Baseline and Follow up

	(1)	(2)	(3)	(4)
$Prior_i^{mean}$	0.972***	0.964***	0.945***	0.938***
	(0.008)	(0.016)	(0.020)	(0.013)
T_1	1.799***	-0.063	1.787***	1.772***
	(0.045)	(0.044)	(0.070)	(0.112)
T_2	1.567***	-0.040	1.773***	1.433***
	(0.074)	(0.045)	(0.095)	(0.147)
$T_1 \times Prior_i^{mean}$	-0.723***	0.017	-0.603***	-0.586***
	(0.022)	(0.019)	(0.032)	(0.046)
$T_2 \times Prior_i^{mean}$	-0.492***	0.006	-0.503***	-0.502***
	(0.039)	(0.018)	(0.046)	(0.061)
Constant	0.025	0.062	0.080*	0.120***
	(0.024)	(0.043)	(0.047)	(0.036)
Period Posterior	Baseline	Baseline	Follow Up	Follow Up
Type of firm	Treated	Connected	Treated	Connected
Observations	999	1,020	510	505
R-squared	0.739	0.955	0.760	0.743

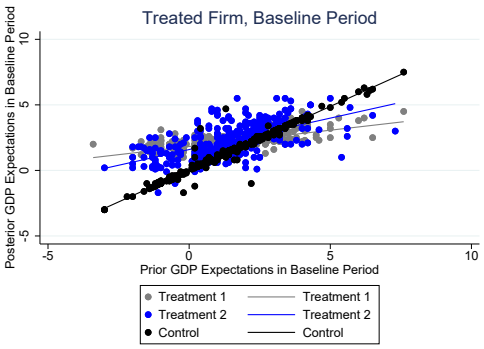
Note. The table reports results of regression 1, where the outcome variables $Posterior_i^{mean}$ is the average GDP forecast of firm i after the treatment. $Prior_i^{mean}$ is the average GDP forecast before the treatment. T_1 is an indicator that is equal to one if firm i received the information treatment about the average GDP forecast and T_2 is an indicator that is equal to one if firm i received the information treatment about the GDP uncertainty. Columns (1) and (2) show results for the baseline survey, and columns (3) and (4) show results for the follow-up survey. Columns (1) and (3) show results for the firms that received the information treatment in the baseline period, and columns (2) and (4) show results for the firms that are connected to the treated firms. Robust standard errors are shown in parentheses.

Table 2 Column (1) shows the direct effect for the treated group. As expected, the estimated correlation between the prior and posterior for the control group – β – is close to one and statistically different from zero. The coefficient $\theta^1 = -0.723$ indicates that treated firms update their priors based on the new information, resulting in a correlation between their prior and posterior to be approximately one-fourth of that estimated for the control firms. Similar but somewhat less pronounced effect is estimated for treatment 2. Panel A of Figure 3 shows the plot of the expectations of our firms.

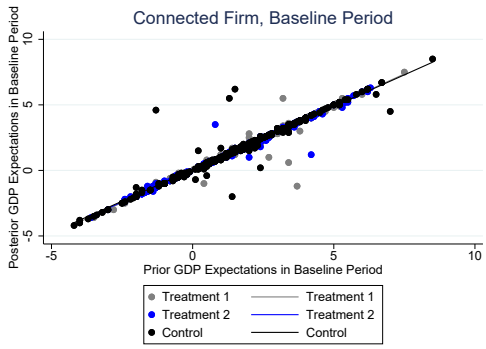
Table 3: Correlation between Prior and Posterior for Treated and Connected Groups in Baseline and Follow-up Periods

Baseline Period

Panel A

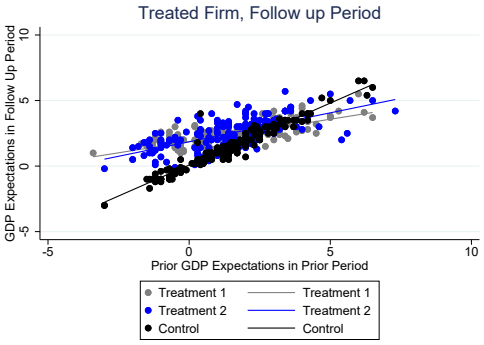


Panel B

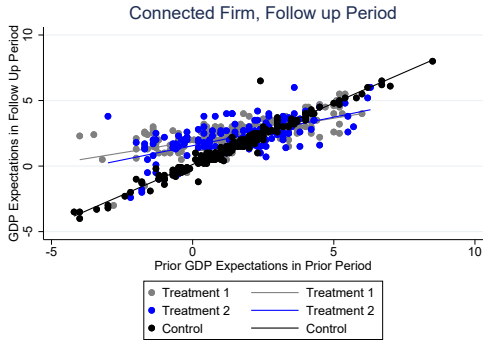


Follow-up Period

Panel C



Panel D



Note: This figure shows a scatter plot of the expectations about GDP asked before the treatment in the baseline period (prior, x axis) with the either the posterior in the baseline period or the expectations in the follow up period (y-axis). Panels A and B plot the prior and the posterior in the baseline period. Panel A does it for the treated firms and Panel B does it for the connected firms. Panels C and D plots the prior expectations in the baseline period with the expectations in the follow up period. Panel C does it for the treated firms and Panel D does it for the connected firms. Each dot represent answers from a firm and lines are linear fit lines for each group. The dark dots and lines represent firms in the the control group. Gray represents firms that receive treatment 1 (average GDP forecast). Blue represents firms that received treatment 2 (about uncertainty).

For firms connected to the treated firms but who do not directly receive the information, we expect the correlation between their instantaneous prior and posterior expectation to be similar to that of the control group. While the effect on β is expected to be close

to 1, there should also be no discernible effect on θ^1 and θ^2, indicating that the correlation between prior and posterior remains unchanged for these firms. Likewise, there should be no significant difference in T_1 and T_2, suggesting no level difference between the groups. As expected, column (2) of Table 2 estimates a null effect. These findings are visually presented in Panel B of Figure 3, where the slopes between the control and treated pairs are indistinguishable.

Now, we turn to the persistent effect of the information treatment. For this, we present in column (3) of Table 2 how the expectations of the treated firms behave in the follow-up period. We find that the correlation between prior and posterior for the control group is almost the same ($\beta = 0.945$ vs. 0.972), showing that there was no contamination in our control group, as they did not change their expectations significantly on average. We can also see that for treated firms, the θ^j is negative and of a similar magnitude compared to the instantaneous effect estimated for the baseline period ($\theta^1 = -0.603$ vs. -0.723), showing that firms receiving the information treatment changed their expectations persistently and used the information to forecast GDP growth in the follow-up period.

Next, we estimate the effect on the persistence of expectations of the connected firms. In column (4) of Table 2, we show the most interesting and novel result of this paper. It shows how the connected firm (i.e., firms that did not directly receive an information treatment but are connected as a supplier or customer to a treated firm) changed their expectations in the follow-up period. We first see that β is similar to the one we estimated for these connected firms in the baseline period. Identical to the directly treated firms, these connected firms' θ^1 and θ^2 are negative and statistically different from zero, and more interestingly, the magnitude is very similar to one estimated for the directly treated firms ($\theta^1 = -0.603$ vs. -0.586). This is only possible if the information provided to the treated firms reaches their connected firms, either through direct communication or by the connected firms inferring the treated firms' expectations based on changes in their actions between the baseline and endline periods. We investigate the communication versus inferring expectation through actions in Section 5.

We also provide the same exercise, but instead of looking at average GDP expecta-

tions, we look at uncertainty. Recall that we measure uncertainty by taking the difference between the highest and lowest GDP expectations in firms' forecasts. We estimate the same specification as Equation 1, but using uncertainty prior and posterior instead. Table 4 shows the results.

Table 4: Treatment Effect on Expected GDP Uncertainty in Baseline and Follow up

	(1)	(2)	(3)	(4)
$Prior_i^{uncertainty}$	0.960***	0.993***	0.978***	0.974***
	(0.019)	(0.010)	(0.019)	(0.018)
T_1	1.395***	0.025	1.310***	2.044***
	(0.198)	(0.084)	(0.302)	(0.328)
T_2	1.145***	-0.015	1.142***	1.139***
	(0.033)	(0.013)	(0.264)	(0.267)
$T_1 \times Prior_i^{uncertainty}$	-0.766***	-0.008	-0.717***	-0.761***
	(0.033)	(0.013)	(0.042)	(0.046)
$T_2 \times Prior_i^{uncertainty}$	-0.720***	-0.008	-0.689***	-0.610***
	(0.031)	(0.014)	(0.042)	(0.046)
Constant	0.220**	0.067	0.187**	0.276**
	(0.095)	(0.070)	(0.090)	(0.122)
Period Posterior	Baseline	Baseline	Follow Up	Follow Up
Type of firm	Treated	Connected	Treated	Connected
Observations	1,012	1,022	514	513
R-squared	0.835	0.973	0.809	0.700

Note. The table reports results of regression 1, where the outcome variables $Posterior_i^{uncertainty}$ is the uncertainty on the GDP forecast of firm i after the treatment, measured as the absolute value on the distance between the most and less likely scenario. $Prior_i^{uncertainty}$ is the uncertainty forecast before the treatment. T_1 is an indicator that is equal to one if firm i received the information treatment about the average GDP forecast and T_2 is an indicator that is equal to one if firm i received the information treatment about the GDP uncertainty. Columns (1) and (2) show results for the baseline survey, and columns (3) and (4) show results for the follow-up survey. Columns (1) and (3) show results for the firms that received the information treatment in the baseline period, and columns (2) and (4) show results for the firms that are connected to the treated firms. Robust standard errors are shown in parentheses.

In terms of uncertainty, we find very similar results as we discussed for the mean treatment. In the baseline, both treatments affect the uncertainty of the treated firms but not of the connected firms as expected. In the follow-up period, both firms are similarly affected by the treatment, showing that information not only about the point estimate is transmitted to the input-output network but also about the uncertainty in the GDP forecast. This

is the second novel finding of the paper: aggregate uncertainty is transmitted through the input-output network either due to connected firms observing changes in the actions of treated firms or information is communicated directly with connected firms. We next evaluate whether firms changed their actions due to the information treatment to estimate an elasticity of changes in expectation to changes in actions.

4 Treatment Effect on Actions

So far, we find that the information treatment influences both the first and second moments of the treated firm's GDP expectations, regardless of whether the treatment provides information about the mean or uncertainty of GDP expectations. More importantly, we demonstrate that similar effects extend to firms connected to the treated firms, even though they do not directly receive the information.

We first estimate Equation 2 to investigate the effect of treatment on actions. The idea is to see if information led firms' actions to be less or more correlated with their initial plans. To do this, we examine four key measures: price, employment, investment, and wages. These are measured both as *planned* changes reported in the baseline survey (ex-ante plans for the next three months) and as actual *actions* recorded in the endline survey (ex-post decisions at the endline).

$$Y_{i,t}^{Action} = \alpha + \beta Y_{i,t-1}^{Plan} + \sum_{j=1}^{2} \gamma^j T_{i,j} + \sum_{j=1}^{2} \theta^j Y_{i,t-1}^{Plan} \times T_{i,j} + \varepsilon_{i,t}, \tag{2}$$

where $Y_{i,t}^{Action}$ is the action the manager reported in the follow-up period. $Y_{i,t-1}^{Plan}$ is the firm's plan reported in the baseline period. As in regression 1 $T_{i,j}$ is a dummy that takes a value of one of the individual i received the treatment j and zero otherwise. We present the results in Table 5.

We find that the treatment reduced the correlation between firms' actions and plans in terms of prices, employment, and investment, while not for wages – where firms in the treated group did not change their actions relative to their plans compared to firms in the

control group. This is true not only for the directly treated firms but also for the firms connected to treated firms. These findings show that treated and their connected firms' actions and plans are less correlated than control firms. Additionally, the magnitudes are similar across treated and connected firms, especially for prices and investment.

Table 5: Treatment Effect on Wage, Employment and Investment plans

	(1) Price	(2) Price	(3) Wage	(4) Wage	(5) Empl	(6) Empl	(7) Inv	(8) Inv
Plan	1.006***	1.012***	0.995***	0.998***	1.014***	1.017***	0.975***	0.979***
	(0.009)	(0.011)	(0.015)	(0.019)	(0.020)	(0.012)	(0.018)	(0.019)
T_1	1.583***	1.841***	-0.024	0.011	2.837***	2.291***	3.448***	3.128***
	(0.136)	(0.136)	(0.019)	(0.041)	(0.540)	(0.498)	(0.199)	(0.205)
T_2	1.722***	1.815***	-0.016	-0.028	3.388***	2.883***	2.819***	2.552***
	(0.125)	(0.125)	(0.016)	(0.028)	(0.568)	(0.472)	(0.190)	(0.167)
$T_1 \times Plan$	-0.323***	-0.401***	0.005	-0.040	-0.741***	-0.491***	-0.679***	-0.625***
	(0.089)	(0.080)	(0.017)	(0.033)	(0.178)	(0.145)	(0.092)	(0.096)
$T_2 \times Plan$	-0.381***	-0.533***	-0.001	-0.005	-1.017***	-0.845***	-0.483***	-0.366***
	(0.068)	(0.081)	(0.021)	(0.023)	(0.196)	(0.181)	(0.081)	(0.069)
Constant	-0.013	-0.041	0.012	0.030	-0.050	0.009	-0.002	-0.012
	(0.022)	(0.026)	(0.011)	(0.028)	(0.074)	(0.047)	(0.030)	(0.029)
Firm	Treated	Connected	Treated	Connected	Treated	Connected	Treated	Connected
Obs	512	506	505	511	508	511	505	512
R-squared	0.715	0.629	0.980	0.981	0.324	0.438	0.577	0.586

Note. The table reports results of regression 2, where the outcome variables are actions that the firm did in the three months before the follow-up survey. Those actions are the change in prices (columns (1) and (2)), change in wages (columns (3) and (4)), change in employment (columns (5) and (6)) and change in investment (columns (7) and (8)). $Plan$ are the plans that the firm had in the baseline survey for the next three months. T_1 is an indicator that is equal to one if firm i received the information treatment about the average GDP forecast, and T_2 is an indicator that is equal to one if firm i received the information treatment about the GDP uncertainty. Columns (1), (3), (5), and (7) show results for the firms that received the information treatment in the baseline period, and columns (2), (4), (6), and (8) show results for the firms that are connected to the treated firms. Robust standard errors are shown in parentheses.

We now estimate the impact of how exogenous changes in expectations change firms' actual economic decisions/actions. To get a clearer sense of the magnitude of the actions, we have to account for the changes in expectations attributable to the information treatment. We follow Kumar et al. (2023) and Georgarakos et al. (2024) and estimate the causal effect of changes in expectations (for the GDP growth and its uncertainty) on firms' actions. We do so by running the following instrumental variable regression where the second stage is given as:

$$Y_{i,t}^{Action} = \alpha + \beta Y_{i,t-1}^{Plan} + \gamma Posterior_i^{mean} + \theta Posterior_i^{uncertainty} + X'_{i,t}\delta + \varepsilon_{i,t}, \quad (3)$$

where $X_{i,t}$ includes priors for mean and uncertainty from the baseline period. The rest of the variables are defined as in specification 1 and 2. Following Georgarakos et al. (2024), we instrument $Posterior_i^{mean}$ and $Posterior_i^{uncertainty}$ by the treatment dummy and the interaction of these with the priors. As we control for priors, this instrument uses the variation coming from the treatment, given the level of priors. Therefore, we can interpret the estimates as a causal relationship between the posterior mean and uncertainty- the portion explained by treatments- and actions. Table 6 shows the results for all firms pooled, where connected are counted as directly treated. Table 7 separates by type of firm

Table 6: Causal Effect of GDP Forecast and Uncertainty on Actions, by Type of Firm

	(1) Price	(2) Inv	(3) Empl	(4) Wage
$Posterior_i^{mean}$	0.292***	0.138	0.868***	0.003
	(0.082)	(0.141)	(0.295)	(0.013)
$Posterior_i^{uncertainty}$	-0.369***	-0.805***	-0.834***	0.005
	(0.031)	(0.058)	(0.121)	(0.007)
Plan	0.741***	0.534***	0.519***	0.990***
	(0.027)	(0.038)	(0.066)	(0.007)
$Prior_i^{mean}$	-0.144**	-0.026	-0.603***	-0.003
	(0.067)	(0.107)	(0.229)	(0.012)
$Prior_i^{uncertainty}$	0.268***	0.594***	0.685***	-0.004
	(0.029)	(0.053)	(0.120)	(0.004)
Constant	0.634***	1.452***	0.194	0.013
	(0.130)	(0.227)	(0.471)	(0.020)
Type	All	All	All	All
Observations	960	959	960	958
R-squared	0.639	0.480	0.272	0.981
F (mean)	143	169.2	140.8	138.3
F (uncert)	592.4	740.8	622.5	599.4

Note. The table reports results of regression 3, where the outcome variables are actions that the firm did in the three months before the follow-up survey. Those actions are the change in prices (column (1)), change in investment (column (2)), change in employment (column (3)) and change in wages (column (4)). $Plan$ are the plans that the firm had in the baseline survey for the next three months. $Posterior_i^{mean}$ is the GDP forecast of the firm in the follow up period. $Posterior_i^{uncertainty}$ is the uncertainty on the GDP forecast of firm i in the follow-up period, measured as the absolute value on the distance between the most and less likely scenario. $Posterior_i^{mean}$ is the GDP forecast of the firm in the baseline period before receiving the treatment and $Prior_i^{uncertainty}$ is the uncertainty forecast before the treatment. We instrument the posterior variables with the priors interacted by the treatment dummy and a treatment dummy. Robust standard errors are shown in parentheses.

Table 7: Causal Effect of GDP Forecast and Uncertainty on Actions, by Type of Firm

	(1) Price	(2) Price	(3) Inv	(4) Inv	(5) Empl	(6) Empl	(7) Wage	(8) Wage
$Posterior_i^{mean}$	0.163	0.412***	0.008	0.161	0.912**	0.558	0.024	-0.015
	(0.114)	(0.116)	(0.224)	(0.176)	(0.419)	(0.365)	(0.026)	(0.012)
$Posterior_i^{uncertainty}$	-0.335***	-0.425***	-0.824***	-0.842***	-0.810***	-0.902***	0.005	0.007
	(0.042)	(0.046)	(0.083)	(0.075)	(0.173)	(0.176)	(0.010)	(0.010)
Plans	0.766***	0.712***	0.486***	0.583***	0.379***	0.644***	0.995***	0.986***
	(0.037)	(0.041)	(0.057)	(0.048)	(0.104)	(0.083)	(0.008)	(0.012)
$Prior_i^{mean}$	-0.061	-0.226**	0.015	-0.011	-0.746**	-0.326	-0.016	0.008
	(0.093)	(0.094)	(0.157)	(0.140)	(0.325)	(0.294)	(0.022)	(0.010)
$Prior_i^{uncertainty}$	0.258***	0.302***	0.571***	0.663***	0.631***	0.787***	-0.009	0.001
	(0.039)	(0.042)	(0.073)	(0.070)	(0.161)	(0.176)	(0.007)	(0.005)
Constant	0.541***	0.717***	1.742***	1.257***	0.444	0.148	0.008	0.009
	(0.168)	(0.200)	(0.355)	(0.307)	(0.766)	(0.533)	(0.031)	(0.028)
Type	Treat	Conn	Treat	Conn	Treat	Conn	Treat	Conn
Observations	485	475	478	481	479	481	479	479
R-squared	0.688	0.601	0.448	0.523	0.174	0.403	0.978	0.983
F (mean)	110.8	69.73	151.8	70.15	118.9	70.32	109.3	66.85
F (uncert)	365.3	247.7	777.3	233.1	402	260.5	386.8	249.2

Note. The table reports results of regression 3, where the outcome variables are actions that the firm did in the three months before the follow-up survey. Those actions are the change in prices (columns (1) and (2)), change in investment (columns (3) and (4)), change in employment (columns (5) and (6)) and change in wages (column (7) and (8)). $Plan$ are the plans that the firm had in the baseline survey for the next three months. $Posterior_i^{mean}$ is the GDP forecast of the firm in the follow up period. $Posterior_i^{uncertainty}$ is the uncertainty on the GDP forecast of firm i in the follow-up period, measured as the absolute value on the distance between the most and less likely scenario. $Posterior_i^{mean}$ is the GDP forecast of the firm in the baseline period before receiving the treatment and $Prior_i^{uncertainty}$ is the uncertainty forecast before the treatment. We instrument the posterior variables with the priors interacted by the treatment dummy and a treatment dummy. Columns (1), (3), (5) and (7) are the regressions for the firms that received the treatment and columns (2), (4), (6) and (8) are for the connected firms. Robust standard errors are shown in parentheses.

Table 6 presents the results for the pooled sample. A one percentage point increase in firms' GDP growth expectations leads to a 0.29 percentage point increase in prices and a 0.9 percentage point increase in employment relative to their initial plans. However, we find no significant effect on investment or wages. For expectations regarding uncertainty, a one percentage point increase in uncertainty leads to a 0.37 percentage point decrease in prices, a 0.81 percentage point decline in investment, and a 0.83 percentage point drop in employment. Once again, we find no significant effect on wages, with the estimated coefficient remaining small.

The opposing effects of the posterior mean and uncertainty on firms' actions align with economic intuition. When firms anticipate economic growth they increase their prices and

employment, as if they were expecting higher demand for their goods. On the other side, higher uncertainty reduces their prices, investment and employment decisions, related with the contractionary effect of higher uncertainty (Baker et al., 2024).

Table 7 examines firm type, distinguishing between directly treated firms and those indirectly treated through their connection with treated firms, as designed in our survey. Notably, distinct patterns emerge: price effects emerging from changes in the posterior mean are driven by connected firms, while employment effects are primarily observed among treated firms. In contrast, changes in posterior uncertainty appear to have a more uniform impact across both treated and connected firms.

Finally, in Table A-3 in Online Appendix A we show that the effect of the treatment on the connected firm does not depend on how strong the relationship with the treated firm, measured as the share of the market that the connected firm has.

These results, adding to the findings of Tables 2, 4 and 5, show that the effects found do not depend on the type of firm and connection. First, connected firms were as affected by the treatment in terms of their expectations and actions compared to the directly treated firms. Second, connected firms pass-through from expectations to actions are of the same magnitude. Third, those effects are not related to the intensity of the relationship or type of relationship. These results suggest that the effect come from communication and it is not related to an specific supply-type of shock, due to actions or updating information the expectations of a particular product of the business relation they have.

Overall, we find that changes in expectations (both first and second moment) have significant effects on firms' decisions; this result confirms Kumar et al. (2023). Additionally, we present a novel finding: changes in expectation affect the connected firms' actions similarly to treated firms. Moreover. These findings suggest that information from treated firms is reaching their connected firms, either through direct communication or by inferring expectations from observed changes in actions. We investigate these channels in Section 5. Additionally, in Section 6, we discuss the implications of this findings for the strength of communication.

Regardless of the transmission channel, our findings have important implications for

the contagion of expectations within the input-output network. From a policy perspective, central banks could leverage this mechanism to strategically disseminate information throughout the economy. At the same time, it also raises concerns about the potential for pessimistic expectations to propagate, amplifying downturns through network effects.

5 Communication vs. Actions

We investigate whether the observed effects on the actions of connected firms stem from the actions of treated firms or direct communication about expectations between treated firms and their suppliers or customers. To analyze this, we estimate the same specification as in Table 7 for connected firms but now control for the actions and expectations of treated firms. The key idea behind this exercise is that if firms did not receive communication about treated firms' revised expectations and only responded to the observed actions of treated firms, then controlling for treated firms' actions should eliminate the effect found for connected firms. If the effect persists, it suggests that expectations reached the connected firms from alternative channels – most likely through communication.

In specification 3, we further control the actions of treated firms, including prices, investment, employment, and wages. We then re-estimate this IV specification exclusively on connected firms. The results are presented in Table A-1 in Appendix A. We find that the effects identified in Table 7 for connected firms remain statistically significant and of a similar value even after controlling for the actions of treated firms—which could have been observed and inferred for expectation formation. We also find that the actions of treated firms are correlated with the decisions of connected firms, particularly in price setting and investment.

That specification has the advantage of removing all measurable actions from the directly treated firm, but the result can be affected by selection bias. The fact that the actions coefficients are not affected significantly are reassuring and might indicate that the selection bias is not strong in that case, for example if actions are not the main driver of the effects. Alternatively, we can run the regression as in 3, but adding the action of the con-

nected firm, instrumenting it by its plan interacted by the treatments. In this version, we can also measure the effect of actions of the other firm. Table 8 shows the results

Table 8: Causal Effects of GDP Forecast, Uncertainty and Others Actions on Connected Firms

	(1) Price	(2) Inv	(3) Emp	(4) Wage
$Posterior_i^{mean}$	0.419***	0.065	0.644*	-0.019
	(0.125)	(0.170)	(0.386)	(0.015)
$Posterior_i^{uncertainty}$	-0.331***	-0.515***	-0.779***	0.007
	(0.071)	(0.103)	(0.217)	(0.011)
$Action\ Other_{j-i}$	0.236*	0.317***	0.091	0.348
	(0.139)	(0.083)	(0.083)	(0.323)
$Plan_i$	0.708***	0.564***	0.643***	0.981***
	(0.042)	(0.051)	(0.086)	(0.014)
$Plan\ Action\ Other_{j-i}$	-0.103	-0.192***	-0.047	-0.346
	(0.139)	(0.072)	(0.071)	(0.323)
$Prior_i^{mean}$	-0.230**	0.023	-0.427	0.013
	(0.099)	(0.138)	(0.314)	(0.012)
$Prior_i^{uncertainty}$	0.230***	0.492***	0.673***	0.002
	(0.063)	(0.086)	(0.209)	(0.006)
Constant	0.486**	0.331	0.079	0.007
	(0.194)	(0.314)	(0.554)	(0.028)
F (mean)	50.68	48.08	60.13	43.98
F (uncert)	187.8	158.7	191	191.9
F (Action O)	45.47	64.57	16.08	0.851
Observations	453	452	454	452
R-squared	0.610	0.490	0.388	0.979

Note. The table reports results of regression 3, where the outcome variables are actions that the firm did in the three months before the follow-up survey. Those actions are the change in prices (column (1)), change in investment (column (2)), change in employment (column (3)) and change in wages (column (4)). $Plan_i$ are the plans that the firm had in the baseline survey for the next three months. $Action\ Other_{j-i}$ are the actions of the directly treated firm that is connected to a firm in this sample. $Plan\ Action\ Other_{j-i}$ are their plans. $Posterior_i^{mean}$ is the GDP forecast of the firm in the follow up period. $Posterior_i^{uncertainty}$ is the uncertainty on the GDP forecast of firm i in the follow-up period, measured as the absolute value on the distance between the most and less likely scenario. $Posterior_i^{mean}$ is the GDP forecast of the firm in the baseline period before receiving the treatment and $Prior_i^{uncertainty}$ is the uncertainty forecast before the treatment. This regression is run for the connected firm. We instrument the posterior variables and $Action\ Other_{j-i}$ with the treatment dummy, priors interacted by the treatment dummy and the plan of the of the directly treated firm that is connected to a firm in this sample. Robust standard errors are shown in parentheses.

We find that the coefficients for both posterior mean and uncertainty do not change significantly after controling for the action, even using the variation induced by the treatment. We find some role for the actions of the connected firm, in particular for investment, but without altering the main effect.

Overall, we find suggestive evidence that treated firms do not primarily transmit their expectations through their actions analyzed. However, other behaviors—such as requests for contractual changes or negotiation tactics—could still serve as signals that reveal expectations. Alternatively, direct firm-to-firm communication may play a role in transmitting information. To investigate this further, we analyze communication patterns and content from treated firms to connected firms. This allows us to provide direct suggestive evidence on the role of communication and whether our treatment influences it.

Table 9 presents four communication variables for treated firms. Column (1) measures how often treated firms directly discussed GDP with their connected firms—our key information treatment. We convert this into a binary variable, assigning 1 if the firm ever discussed GDP within the three-month period and 0 otherwise. Columns (2)-(4) capture the traditional frequency of discussions about the product, industry, and economy between treated and connected firms. Responses range from daily to less than annually, and we create a binary measure coded as 1 if the discussion occurred within the three-month period (i.e., quarterly or more frequent), and 0 otherwise. These communications are related to the product, industry, and economy in a broader sense. Using these variables, we estimate the treatment effect on these communication measures.

Our key findings are in column (1) of Table 9. 35% of control firms report discussing GDP with their connected firms, but in the treated group, this increases by 42–50 percentage points (depending on the treatment), indicating a substantial rise in GDP-related communication due to the treatment. At the intensive margin, in column (1) of Appendix Table A-2 and Figure 1 shows the treated firms have reported having discussed the GDP-related information with connected firms 3 additional times compared to the control group, where discussions occur fewer than once on average in 3 months. These results strongly suggest that one of the channels through which expectations and actions

changed among connected firms is driven by the rise in GDP-related discussions from treated to connected firms.

The next three columns reveal that 80%–90% of control firms already discuss product and industry trends regularly. While the treatment is associated with traditionally more product-related discussions among treated firms, the effect size is much smaller, and industry-related discussions remain unchanged. Finally, only 27% of firms in the control group discuss the broader economy. Traditionally, general economic discussions are not a central focus in firm-to-firm interactions, which is why our information treatment was new information, and it also made the firms change the content of their discussion. In Appendix Table A-2, we also show that firm-to-firm communication does not exhibit strategic selectivity, as firms engage in discussions with their suppliers or customers equally (three times more than the control group on average). This analysis underscores the role of direct firm communication in the transmission of macroeconomic expectations, reinforcing the link between information exchange and decision-making within business networks.

Table 9: Treatment Effect on Frequency & Content of Communication

	(1)	(2)	(3)	(4)
	Follow-up GDP Comm. Comm. > 0	**Follow-up Product Comm. Freq. < Quarter**	**Follow-up Industry Comm. Freq. < Quarter**	**Follow-up Economy Comm. Freq. < Quarter**
Treatment 1	0.498***	0.0658**	0.0214	0.0676
	(0.048)	(0.027)	(0.045)	(0.053)
Treatment 2	0.423***	0.0759***	0.0593	0.0387
	(0.052)	(0.026)	(0.043)	(0.053)
Control Mean	0.351	0.904	0.806	0.272
Observations	456	478	448	451

Notes: The table reports ordinary least square (OLS) estimations at the firm level. Outcome variables include a dummy equals 1 if the communication between the treated and connected firm (about GDP) is non-zero, zero otherwise (col 1); a dummy equals 1 if the firm typically communicates with its connected firm about its product/industry trends/economic trends at a lower frequency than quarterly, zero otherwise (col 2,3,4). The robust standard errors are shown in parentheses.

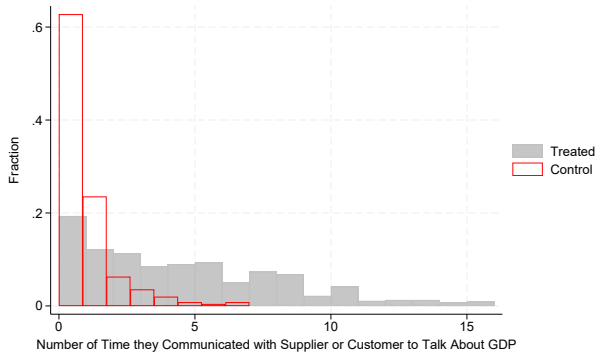


Figure 1: Communication Between Firms

Note: This figure shows the fraction of firms in the treated and control groups that reported having communicated with their supplier or customer sampled in this experiment about GDP in the past three months. The gray bars show the fraction of responses for the treated group and the red bars show them for the control group.

This section shows that firms communicate regularly and that treated firms communicated about the information we gave them. We also show suggestive evidence that the actions of connected firms are less likely to be the reason for connected firms' actions to change. Instead, we show that connected firms' changes in expectation explain their actions. In the next section, we introduce communication in a production network model to understand the role of communication in firms' expectation formation and pricing decisions. We also explore the macroeconomic implications of communication between firms.

6 Role of Communication

In this section, we explore the role of communication for firms' pricing decisions through the lens of a production network model. Our rationale for focusing on pricing decisions alone is that they are the key link between supplier and customer firms in a supply chain network. To that end, our framework will help us distinguish between the role that communication versus firms' actions (prices) play in amplifying information treatments received by individual firms.

6.1 Setup

We consider the sector-level Phillips curve derived in Rubbo (2023). For the purposes of our paper, each sector is represented by a firm. The optimal firm-level inflation rates, $\boldsymbol{\pi}_t = \boldsymbol{p}_t - \boldsymbol{p}_{t-1}$, are given by

$$\boldsymbol{\pi}_t = \beta\Omega\widetilde{\mathbb{E}}_t\left[\boldsymbol{\pi}_{t+1}\right] + \boldsymbol{\kappa}y_t - (I-\Omega)\boldsymbol{p}_{t-1} \tag{4}$$

where $\boldsymbol{p}_t$ is the price vector; $\widetilde{\mathbb{E}}_t$ is a *generic* expectations operator, possibly different from the full-information rational expectations one; y_t is a measure of slack in the economy, assumed to be captured by output growth in deviation from its steady-state; β denotes the discount factor; Ω is a matrix whose elements are convoluted expressions of the intensity of input-output linkages ($IO = [\iota_{ij}]$ matrix) among firms as well as their labor shares and Calvo probabilities of price adjustment. The elements of each row in Ω sum to 1. We re-write the equation above in terms of the price vector:

$$\boldsymbol{p}_t = \Delta\left(\boldsymbol{\kappa}y_t + \beta\Omega\widetilde{\mathbb{E}}_t\left[\boldsymbol{p}_{t+1}\right] + \Omega\boldsymbol{p}_{t-1}\right) \tag{5}$$

where $\Delta = (I+\beta\Omega)^{-1}$ and expectations about the future price vector depend on expectations about future output growth. Output growth is assumed to be exogenously given and follows the process

$$y_{t+1} = \mu_t^* + \varepsilon_{t+1} \tag{6}$$

Similar to Ilut and Schneider (2014), we assume that output growth has two components: an iid shock, ε_t, with mean zero and variance σ_ε^2, and a deterministic sequence μ_t^*. The long-run behavior of μ_t^* is assumed to converge to that of an iid normal stochastic process with mean 0 and stadard deviation σ_{μ^*} that is independent of the process for ε_t. Firms, however, cannot distinguish the deterministic sequence from the iid shocks even if they observe an infinitely large amount of data. As a result, equation (6) describes a large family of possible processes – all indistinguishable even with a large amount of data – that can have rather different implications in the short run, for example because they differ in the conditional mean μ_t^*.

6.2 Output Growth Expectations

Iterating equation (5) forward, it becomes clear that firms' expectations about future output growth are important for firms to pin down their current optimal decisions. Hence, to solve the model we have to discipline firms' expectations about future growth. In doing so, we consider three components. First, we assume that firms are averse to ambiguity in light of the uncertainty they face about the deterministic component of output growth. Second, firms can receive noisy signals about μ_t^* and the ambiguity of professional forecasters $|a_t|$, which they can incorporate into their growth expectations. Third, firms can communicate their output growth expectations to each other.

Ambiguity aversion. Even though firms are risk neutral, they are assumed to be ambiguity averse. Ambiguity arises due to the fact that firms are generally not able to distinguish the deterministic component from the iid component of growth, implying that there are many possible combinations of histories of μ_t^* and ε_{t+1} that would give rise to the same path of output growth. To discipline the firms' belief set for output growth, we follow a strategy similar to Ilut and Schneider (2014). Specifically, the perceived law of motion for output of any firm i is given by

$$y_{t+1} = \mu_{it} + \varepsilon_{i,t+1}, \qquad \mu_{it} \in [-a_{it}, -a_{it} + 2|a_{it}|] \tag{7}$$

where firm i perceives the deterministic component of growth to range between $-a_{it}$ and $-a_{it} + 2|a_{it}|$ with $a_{it} \sim \mathcal{N}(0, \sigma_a^2)$ describing its ambiguity around a forecast of no output growth (in deviation from steady state). More broadly, $-a_{it}$ quantifies the quality of intangible information available in period t about output growth in period $t+1$, relative to some steady-state level of information quality. Due to ambiguity aversion, firms base their actions on the most pessimistic possible outcome, that is, their prior expectations about future output growth are given by

$$\widetilde{\mathbb{E}}_{it}^{prior} y_{t+1} = \min_{\mu_{it} \in [-a_{it}, -a_{it}+2|a_{it}|]} \mathbb{E}_{it}^* y_{t+1} = -a_{it} \tag{8}$$

where $\mathbb{E}_{it}^* y_{t+1}$ denotes the conditional first moment of future growth under the guessed

worst case belief.

Information treatments. As in the experiment, a subset of firms $\mathcal{F}_\mu$ receives a noisy signal about the professional forecasters' projection of μ_t^*, another subset $\mathcal{F}_a$ receives a noisy signal about professional forecasters' ambiguity $-a_t$, and the remaining set of firms do not receive any information:

$$s_{it} = \begin{cases} \mu_t^* + v_{it}, \quad v_{it} \sim \mathcal{N}(0, \sigma_v^2) & \text{if } i \in \mathcal{F}_\mu \\ -a_t + u_{it}, \quad u_{it} \sim \mathcal{N}(0, \sigma_u^2) & \text{if } i \in \mathcal{F}_a \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

where the noise shocks v_{it} and u_{it} are assumed to be uncorrelated with each other, uncorrelated with μ_t^* and $-s_t$, and uncorrelated across treated firms. After treatment, firms update their expectations to

$$\widetilde{\mathbb{E}}_{it}^{post} y_{t+1} = -a_{it}(1 - g_i) + g_i s_{it} \tag{10}$$

where $g_i \in \left\{0, \frac{\sigma_{\mu^*}^2}{\sigma_{\mu^*}^2 + \sigma_v^2}, \frac{\sigma_a^2}{\sigma_a^2 + \sigma_v^2}\right\}$ denotes the Kalman gain and captures the extent to which firms update their expectations in response to the information treatments.

Communication. Consistently with the evidence, firms communicate their expectations about future output growth with each other. We assume that firms take the communication network as given.[6]

DEFINITION 1. *The communication network is described by matrix $\mathcal{C} = [c_{ij}]$, where $c_{ij} \in [0, 1]$ quantifies the intensity with which firm j communicates its expectations about future output growth to firm i, so that $\sum_{j=1}^{N} c_{ij} = 1$. There is no communication between any two non-trading firms.*

Given the definition of the communication network, the *final* firm i's growth expectations are given by

[6]Since the communication network is exogenously given, we abstract from firms strategically choosing to communicate parts of information with other firms.

$$\widetilde{\mathbb{E}}_{it} y_{t+1} = \underbrace{\left(1 - \sum_{j \neq i}^{N} c_{ij}\right)}_{=c_{ii}} \widetilde{\mathbb{E}}_{it}^{post} y_{t+1} + \sum_{j \neq i}^{N} c_{ij} \widetilde{\mathbb{E}}_{jt}^{post} y_{t+1} \tag{11}$$

where $\sum_{j \neq i}^{N} c_{ij} = (1 - c_{ii})$ is a proxy for the total gain in useful information from communication. The vector of all firms' expectations about future growth can be written as

$$\widetilde{\mathbb{E}}_t \boldsymbol{y}_{t+1} = \mathcal{C}\left[-(I - G)\boldsymbol{a}_t + G\boldsymbol{s}_t\right] \tag{12}$$

where $\boldsymbol{y}_t = \mathbf{1} y_t$, $\boldsymbol{a}_t$ is the vector of firm-specific ambiguity, G is a diagonal matrix whose diagonal equals the vector of Kalman gains $\boldsymbol{g}$; and $\boldsymbol{s}_t$ is the vector of signals.[7]

6.3 Solution and Implications

Proposition 1 describes the solution of the model and shows that the optimal price level depends on current output growth, vector of past prices, vector of current ambiguity, and vector of signals.

PROPOSITION 1. *The equilibrium price vector is given by the following expression:*

$$\boldsymbol{p}_t = M_s \boldsymbol{s}_t + M_y \boldsymbol{y}_t + M_a \boldsymbol{a}_t + M_p \boldsymbol{p}_{t-1}.$$

PROOF. See Appendix C.1. □

The first-order effect of an information treatment about future growth on the current price vector results from the interaction of two effects: the effect of information on growth

[7] We note that if there is no ambiguity aversion, that is, $a_{it} = 0$ for any firm i and $a_t = 0$; and ii) there is perfect information about μ_t^*, that is, all firms receive a precise signal about μ_t^*, then the model recovers Rubbo (2023).

expectations and the effect of growth expectations on current prices, as shown below.

$$\frac{\partial \boldsymbol{p}_t}{\partial s_{jt}} = \underbrace{\left[\frac{\partial \boldsymbol{p}_t}{\partial \widetilde{\mathbb{E}}_t \boldsymbol{p}_{t+1}} \frac{\partial \widetilde{\mathbb{E}}_t \boldsymbol{p}_{t+1}}{\partial \widetilde{\mathbb{E}}_t \boldsymbol{y}_{t+1}}\right]}_{\text{expectations effect on actions}} \times \underbrace{\frac{\partial \widetilde{\mathbb{E}}_t \boldsymbol{y}_{t+1}}{\partial s_{jt}}}_{\text{info effect on expectations}} \tag{13}$$

The first-order effect on the price vector will trigger an update in firms' expectations about future prices which will feed into current prices, and so on. To that end, Proposition 2 describes the equilibrium effect of an information treatment on the price vector.

PROPOSITION 2. *In equilibrium, the effect of the information treatment received by firm j on the price vector is described by*

$$\frac{\partial \boldsymbol{p}_t}{\partial s_{jt}} = \beta \times M \times \frac{\partial \widetilde{\mathbb{E}}_t \boldsymbol{y}_{t+1}}{\partial s_{jt}} = \beta \times g_j \times M \times \mathcal{C}_{:,j} \tag{14}$$

where $M = M_p M_y$ and $\mathcal{C}_{:,j}$ is the j^{th} column of the communication matrix. All entries of M are positive so that a signal about higher μ_t^* or lower ambiguity will cause firms to increase prices.

PROOF. See Appendix C.2. □

Using Proposition 2, we decompose the equilibrium effect of a treatment received by firm j on the current price of firm i as follows

$$\frac{\partial p_{it}}{\partial s_{jt}} = \underbrace{\beta g_j M_{ij} c_{jj}}_{\text{treated firm action channel}} + \underbrace{\beta g_j \sum_{k \neq j} M_{ik} c_{kj}}_{\text{treated firm communication channel}} \geq 0. \tag{15}$$

The first component describes the effect of treatments to the extent that the actions of the treated firm affect firm i, as captured by M_{ij}. The second component describes the communication effect that results from the treated firm sharing information with its production network (including i) and those firms reacting to the new information. If there is no communication, the effect of the information treatment received by firm j on the price vector is described by $\frac{\partial p_{it}}{\partial s_{jt}} = \beta g_j M_{ij} \geq 0$. On the other hand, the more communication there is, the more important the communication channel becomes for the effect of

treatments on prices. As a result, we should observe less heterogeneity in firms' pricing decisions following a firm-specific information treatment.

COROLLARY 1. *Let the firm pairs (i, j) be a supplier-customer pair so that $M_{ij} < M_{ji}$. Suppose that both firms update expectations similarly to the same information treatment ($g_i = g_j$) and there is no communication between the two firms. Then, the response of the customer firm price to treatments received by its supplier should be higher than the response of the supplier firm price to treatments received by its customer.*

Corollary 1 describes the key counterfactual implication of the model when there is no communication on the supply chain. Importantly, it shows that to rationalize the finding that suppliers' and customers' prices and expectations respond symmetrically, it has to be that firms communicate with one another.

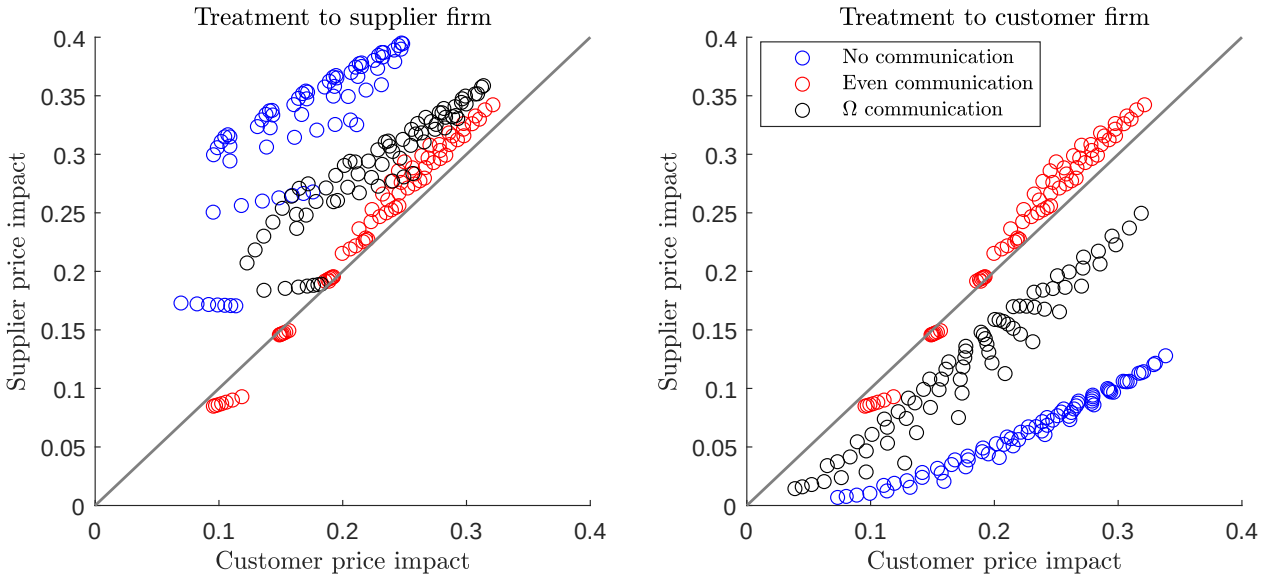
6.4 Quantitative Application

In this section, we explore the role of communication quantitatively. Specifically, we consider a 3-firm network where, similar to Rubbo (2023), one of the firms represents the labor union. The other two firms are connected with each other through a supplier-customer relationship. We consider a structure of the IO production network where the first firm is the labor union with labor share equal to 1, the second firm is a supplier to the third firm and customer to the union, the third firm is a customer to the other two firms.[8] From hereafter, we'll refer to the second firm as the supplier and the third firm as the customer. In this baseline exercise, we fix $\iota_{31} = 0.15$ and compute the impact of signals on prices while varying ι_{21} and ι_{32}. We note that the sum of the rows of IO equal unity minus the labor share of the firm associated with that row. We further set the discount factor equal to 0.99, assume that the probability that any firm adjusts the price is 0.8, and let the Kalman gain be equal to 0.9.

[8] Specifically, $IO = \begin{bmatrix} 0 & 0 & 0 \\ \iota_{21} & \iota_{22} & 0 \\ \iota_{31} & \iota_{32} & \iota_{33} \end{bmatrix}$.

Figure 2 scatter plots the customer and supplier's price impacts of a treatment about either the first or second moment of growth, for various parameterizations of the IO network. In the left panel the supplier firm is the treated firm, whereas in the right panel the customer firm is the treated one. The figure further distinguishes between the various communication strategies among firms: we plot in blue the price impacts when there is no communication among firms, in red the price impacts when there is even communication among firms, that is, when $\mathcal{C} = \mathbf{1}_{N,N}/N$, and in black the case when the communication matrix coincides with the Ω matrix.

Figure 2: Correlation between treated and connected firms prices after treatment

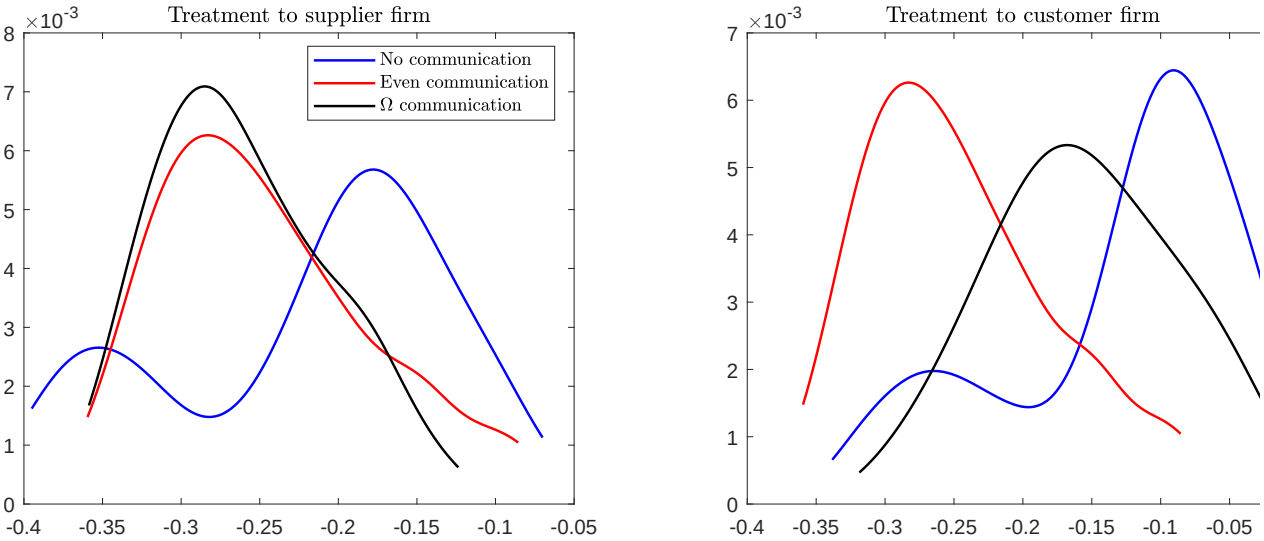


Note. Left panel plots the correlation between the price impact of the treated firm and connected firm, when the treated firm is the supplier. Right panel plots the correlation between the price impact of the treated firm and connected firm, when the treated firm is the customer firm. In red: there is complete and even communication among firms; in blue: no communication; in black: the communication matrix equals Ω. In gray: 45-degree line.

The right panel of the figure visualizes the counterfactual implication of Corollary 1 in the absence of communication: When the treated firm is a customer firm, its supplier will change the price to the extent that there is feedback from the production network alone as captured by element $M_{supplier,customer}$ in matrix M (which is typically small since $IO_{supplier,customer} = 0$). As a result, the supplier will change its price a lot less than the treated, customer firm. This remains the case when the communication network is as-

sumed to be the same as the IO network. By contrast, when there is even communication among firms, the price responses lie on the 45-degree line, irrespective of which firm receives the treatment. The left panel shows that the effects of communication are less pronounced when the treated firm is the supplier, since the customer firm will be responsive to its suppliers' actions by design. However, as in the right panel, communication among firms homogenizes the price impact of the treatment.

Figure 3: Distribution of firm-specific inflation rates after a treatment of higher uncertainty



Note. In red: there is complete and even communication among firms; in blue: no communication; in black: the communication matrix equals Ω.

Figure 3 plots the distribution of firm-specific inflation rates in response to an information treatment about higher growth uncertainty provided to the supplier in the left panel and to the customer in the right panel. As expected, all firms adjust their prices downward, but the adjustment is more pronounced when there is communication.

6.5 Discussion of Macroeconomic Implications

The model and quantitative analysis provide insights into the implications of communication in a production network. First, the model shows that communication can amplify the effects of firm-specific expectational shocks on all firms' price changes leading to more inflation volatility, especially when the shocks originate from downstream firms. Second,

the empirical findings emphasize that firms' expectations about future inflation should be properly accounted for when estimating the slope of the Phillips curve for three reasons: i) prices respond to shocks about expected future output growth, ii) firm-specific shocks about future aggregate growth have spillover effects to other firms' pricing decisions due to the production network, and) communication amplifies such spillover effects.[9] As a result, controlling for firms' expectations is even more important in the context of production networks complemented by communication networks to avoid over-estimating the slope of the Phillis curve. Finally, the finding that information spreads through the production network can help policy makers design more effective policies to mitigate economic volatility stemming from expectations.

7 Conclusion

Using a randomized controlled trial applied to a sample of firm-firm pairs, we examine the role that input-output linkages play for the expectations formation process of firms. Exploiting exogenous variation from an information treatment—which provided either GDP forecasts or uncertainty forecasts—we show that firms update their expectations, and these revisions lead to changes in economic decisions, including pricing, investment, and employment.

Notably, the effect of information treatments on expectations and key decisions is observed not only among the directly treated firms but also among firms connected to them, suggesting that information propagates beyond those who receive it firsthand. To understand the mechanism of transmission, we assess whether connected firms adjust expectations and decisions in response to observed actions of treated firms or through direct communication. Our findings provide suggestive evidence that communication—not merely changes in the treated firms' actions—drives expectation updates and economic decisions among connected firms.

[9] Beaudry et al. (2025) show that the Phillips curve is estimated to be flat when controlling for the private sector's inflation expectations but steep when not doing so.

To better asses communication as a transmission mechanism of shocks, we integrate a communication network into a production network model to examine its impact on the expectations of firms, their pricing decisions, and macroeconomic outcomes. Quantitatively, we find that without communication the response of firms' expectations and pricing decisions to information treatments diverge, whereas with communication, expectations and decisions align more symmetrically. We show that communication can amplify the effects of firm-specific expectational shocks on the pricing decisions of all firms leading to more inflation volatility. Therefore, understanding the communication-driven transmission mechanism of shocks can help design more effective stabilization policies to mitigate economic volatility. In light of out results, we argue that, when a production network is complemented by a communication network, controlling for firms' expectations is even more important to avoid an over-estimation of the Phillis curve slope.

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Online Appendix

March 20, 2025

A Other Tables and Figures

Table A-1: Causal Effect of GDP Forecast and Uncertainty on Actions by Connected Firms, Controlling by Treated Actions

	(1) Price	(2) Inv	(3) Emp	(4) Wage
$Posterior_i^{mean}$	0.367***	0.236	1.057**	-0.013
	(0.123)	(0.209)	(0.413)	(0.012)
$Posterior_i^{uncertainty}$	-0.326***	-0.605***	-0.655***	0.017
	(0.061)	(0.090)	(0.232)	(0.012)
$Plans_i$	0.706***	0.554***	0.707***	0.983***
	(0.045)	(0.058)	(0.091)	(0.015)
$\Delta Price^{Tr}$	0.182***	0.160***	-0.116	0.012
	(0.037)	(0.055)	(0.098)	(0.008)
ΔInv^{Tr}	0.052**	0.050	0.026	0.004*
	(0.025)	(0.036)	(0.086)	(0.002)
ΔEmp^{Tr}	-0.012	0.008	0.037	-0.001
	(0.010)	(0.020)	(0.043)	(0.001)
$\Delta Wage^{Tr}$	-0.050	-0.051	0.078	0.000
	(0.051)	(0.072)	(0.215)	(0.005)
$Prior_i^{mean}$	-0.198**	-0.078	-0.737**	0.010
	(0.099)	(0.164)	(0.340)	(0.011)
$Prior_i^{uncertainty}$	0.235***	0.507***	0.563**	-0.007
	(0.049)	(0.081)	(0.221)	(0.004)
Constant	0.484**	0.814**	0.074	-0.016
	(0.227)	(0.348)	(0.567)	(0.028)
Observations	384	388	388	385
R-squared	0.626	0.488	0.432	0.987
F (mean)	50.75	54.37	48.83	51.30
F (uncert)	136.9	131.6	138.5	138.7

Note. The table reports results of regression 3, where the outcome variables are actions that the firm did in the three months before the follow-up survey. Those actions are the change in prices (column (1)), change in investment (column (2)), change in employment (column (3)) and change in wages (column (4)). $Plan$ are the plans that the firm had in the baseline survey for the next three months. $Posterior_i^{mean}$ is the GDP forecast of the firm in the follow up period. $Posterior_i^{uncertainty}$ is the uncertainty on the GDP forecast of firm i in the follow-up period, measured as the absolute value on the distance between the most and less likely scenario. $Posterior_i^{mean}$ is the GDP forecast of the firm in the baseline period before receiving the treatment and $Prior_i^{uncertainty}$ is the uncertainty forecast before the treatment. This regression is run for the connected firm. $\Delta Price^{Tr}$, ΔInv^{Tr},ΔEmp^{Tr} and $\Delta Wage^{Tr}$ are the price change, investment change, employment change and wage change of the treated firms in the follow up survey (actions). We instrument the posterior variables with the priors interacted by the treatment dummy and a treatment dummy. Robust standard errors are shown in parentheses.

Table A-2: Number of Times Communicate with Supplier about GDP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment (T)	3.389***	3.597***	3.161***	3.597***	3.391***	3.385***	3.391***	3.322***
	(0.170)	(0.240)	(0.239)	(0.240)	(0.239)	(0.241)	(0.239)	(0.332)
Connected (Conn)				0.029				
				(0.149)				
Conn x T				-0.436				
				(0.339)				
Supplier (Su)							0.102	
							(0.149)	
T x Su							-0.006	
							(0.339)	
Conn x (1-Su)								-0.204
								(0.195)
T x Su								-0.121
								(0.203)
Conn x Su								0.129
								(0.231)
T x Conn x Cus								0.154
								(0.477)
T x (1-Conn) x Su								0.580
								(0.479)
T x Conn x Su								-0.439
								(0.471)
Constant	0.663***	0.649***	0.677***	0.649***	0.612***	0.714***	0.612***	0.704***
	(0.074)	(0.103)	(0.107)	(0.103)	(0.101)	(0.109)	(0.101)	(0.156)
Type of Firms	All	Treated	Conn	All	Customer	Su	All	All
Observations	814	424	390	814	407	407	814	814
R-squared	0.209	0.219	0.199	0.212	0.212	0.206	0.209	0.214

Table A-3: Strength of Relationship, Expectations and Actions

	(1) GDP	(2) Wage	(3) Employment	(4) Investment	(5) Price
Prior	0.929***	0.999***	1.042***	0.966***	1.001***
	(0.016)	(0.035)	(0.026)	(0.023)	(0.013)
T_1	1.720***	-0.000	1.846***	2.776***	1.800***
	(0.141)	(0.059)	(0.628)	(0.226)	(0.155)
T_2	1.413***	-0.045	2.041***	2.398***	1.580***
	(0.208)	(0.048)	(0.739)	(0.222)	(0.207)
$T_1 \times Prior$	-0.566***	-0.042	-0.533**	-0.662***	-0.470***
	(0.061)	(0.047)	(0.228)	(0.117)	(0.099)
$T_2 \times Prior$	-0.553***	0.007	-1.154***	-0.410***	-0.548***
	(0.088)	(0.036)	(0.260)	(0.098)	(0.133)
$T_1 \times Prior \times Share$	0.001	-0.001	0.023*	-0.012	0.002
	(0.003)	(0.002)	(0.012)	(0.009)	(0.009)
$T_2 \times Prior \times Share$	0.002	0.001	0.015	-0.009	0.002
	(0.004)	(0.002)	(0.020)	(0.010)	(0.019)
$Prior \times Share$	-0.005***	-0.001	-0.003	0.003*	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Share$	0.016***	-0.001	-0.033	-0.006	-0.011*
	(0.005)	(0.001)	(0.023)	(0.008)	(0.007)
Constant	0.092**	0.046	0.045	-0.003	-0.015
	(0.045)	(0.044)	(0.094)	(0.047)	(0.032)
Observations	334	335	341	341	314
R-squared	0.755	0.985	0.413	0.556	0.580

B Power Calculations

With the sample size of 150 (N_1=75 treated and N_2=75 control pairs), significance (α) equal to 5% and power ($1-\kappa$) equal to 80%, the minimum detectable effect (MDE) is $0.46SD$. When we vary the sample size to 200, $MDE = 0.398SD$.

Based on a pilot we collected information for 20 pairs of firms: 10 treated and 10 control. We are interested in network effects so we provide the power analysis for untargetted treated firms. The estimated effect size of treatment on the untargeted firm's mean GDP expectations in the follow-up was 1.39, significant at the 5% level.

We repeat the same estimation for the effects on economic decisions of the untargeted firms. The effect size for prices, investment, and employment are 3.39, 1.45, and 3.24,

respectively. For wages, we detect zero effect in the pilot. We summarize this information in the table below:

	Pilot Estimated Effect Size	**Minimum Detectable Effect**	
		N=150	N=200
GDP mean forecast	1.39		
Prices	3.39		
Employment	1.45	0.460	0.398
Investment	3.24		
Wages	-		

Table B-1: Power Calculation

Notes. The variables are all corresponding to the follow-up wave for the linked firm. The effect sizes are in units of standard deviation.

B.1 Outcomes

Primary Outcomes: We are primarily focused on two key outcomes: Macroeconomic Expectations and Economic Decisions.

Expectations. Macroeconomic expectations come from the baseline surveys (priors) and endline surveys (posteriors).

1. The baseline survey collects the priors using the following questions:

    - *What do you think will be the annual growth rate of real GDP in New Zealand in twelve months? Please provide an answer in percentage terms.*
      Answer: . . . . . % per year
    - *Could you provide us with an approximate range of what you think annualized real GDP growth in New Zealand will be over the next 12 months?*
      Answer: Real GDP growth over the next 12 months will be between ..... % per year (lowest forecast) and ..... % per year (highest forecast)
    - **This question is directed exclusively to firms that received the treatment.** *Please let me know what you perceive as the most pessimistic, the most likely, and most optimistic real GDP growth rate for New Zealand over the next 12 months. What*

do you think the lowest annualized real GDP growth rate might be for this time period, what do you think the most likely might be, and what do you think the highest might be? (please provide an answer as % per year).
Lowest real GDP growth rate: …….. % per year
Most likely GDP growth rate: …….. % per year
Highest real GDP growth rate: …….. % per year

2. The endline survey collects this information using the following question:

   - *Please let me know what you perceive as the most pessimistic, the most likely, and most optimistic real GDP growth rate for New Zealand over the next 12 months. What do you think the lowest annualized real GDP growth rate might be for this time period, what do you think the most likely might be, and what do you think the highest might be? (please provide an answer as % per year).*
     Lowest real GDP growth rate: …….. % per year
     Most likely GDP growth rate: …….. % per year
     Highest real GDP growth rate: …….. % per year

Economic Decisions. The second outcome examines firm's economic decisions (relating to the prices, employment, investment and wages).

1. The baseline survey collects the predictions of how the firm plans to change the prices over the next three months (prior to the information provided about the GDP forecast).

   - *Over the next 3 months, by how much (in % changes relative to current level) do you expect to change:*
     a) The price of your main product: …… %
     b) Investment in capital goods: …… %
     c) Employment at your firm: …… %
     d) Average wages: …… %

2. The endline surveys ask the respondent the actual actions taken by the firm using the following question:

   - *Over the last 3 months, by how much (in % changes) did you change:*
     a. The price of your main product: ..... %
     b. Investment in capital goods: ..... %
     c. Employment at your firm: ..... %
     d. Average wages: ..... %

Secondary Outcomes. In terms of secondary outcomes, we consider the communication and information transmission between firms. To avoid priming the firms about their communication and information processed in relation to their connected firms or the value they place on the information from connected firms, we only included a module on these outcomes in the endline.

Supply chain Dependent Expectation. We include the reasons behind the manager's responses on endline expectations to be related or unrelated to supply chain considerations. We measure this using the following question in the endline:

- *What are the primary reasons behind your expectation of GDP growth and its range in question 2? Please select relevant options. Multiple answers are allowed.*
  a. My customer/main supplier firm XXX changed fundamental factors (such as price, quantity, inputs), providing insights
  b. My customer/main supplier firm XXX directly shared information about GDP growth and uncertainty.
  c. Various other firms in your network changed fundamental factors or shared information.
  d. Public sources (such as government, central bank announcements) of information.
  e. Other: Please specify .....

Communication. The endline survey includes the following questions to quantify the frequency of communication for different topics between firms.

- *In general, how often do you communicate with your customer/main supplier firm XXX:*

  a. About your product transactions

  i. Daily

  ii. Weekly

  iii. Monthly

  iv. Quarterly

  v. Semi-annually

  vi. Annually

  vii. Less frequently than annually

  b. About industry trends and conditions

  i. Daily

  ii. Weekly

  iii. Monthly

  iv. Quarterly

  v. Semi-annually

  vi. Annually

  vii. Less frequently than annually

  c. About economic trends and conditions

  i. Daily

  ii. Weekly

  iii. Monthly

  iv. Quarterly

  v. Semi-annually

  vi. Annually

  vii. Less frequently than annually

- *In general, if you had to place a dollar value on the information that you acquire from your*

customer/main supplier firm XXX about product transactions, industry trends and conditions and economic trends and conditions each year, how much do you think that $ value would be? Please use minimum as $0 and maximum as $1000.

Answer: …….. $ per year for information on product transactions

…….. $ per year for information on industry trends and conditions

…….. $ per year for information on economic trends and conditions

- *What are the primary reasons you would share information about GDP growth and uncertainty with your customer/main supplier firm XXX? Please select relevant options. Multiple answers are allowed.*

  a. To reduce operational costs

  b. To comply with legal requirements

  c. To foster innovation and collaboration

  d. To gain a competitive advantage

  e. To foster trust

  f. To address common sectoral challenges

  g. I do not share information about GDP growth or uncertainty with my customer/main supplier firm XXX.

  h. Other: Please specify ……..

- *Over the last three months, how many times did you communicate with your customer/main supplier firm XXX about GDP?*

  Answer: …… times over the last three months

Control variables. We include the battery of control variables for firm-specific variables such as age, size, market share, labor share of total revenue, and manager-specific variables such as the education level and work experience at the current firm. We include these control variables to gain more precision, if the variables do not add additional precision, we only use these variables for heterogeneity analysis.

Main Survey

Preliminary Admin Questions

(This is not part of the survey. Survey company verifies this prior to survey)

Ask this question to customer firm: Your firm is listed in the database at New Zealand Market Research and Surveys Limited. The database indicates that XXX (firm name) is your main supplier of the main product line. Is this information correct?

1. Yes
2. No

Ask this question to main supplier firm: Your firm is listed in the database at New Zealand Market Research and Surveys Limited. The database indicates that XXX (firm name) is one of your customers. Is this information correct?

1. Yes
2. No

Section A. Firm Characteristics

1 **How many years old is the firm?**

Answer: _____ years

2 **How many workers are employed in this firm?**

Answer: _____workers

3 **Out of the total revenue of the firm, what fraction is used for compensation of all employees and what fraction is used for the costs of materials and intermediate inputs (raw materials, energy inputs, etc...)?**

Share of revenues:

Labor cost _____ % , Cost of materials _____ %

4 **For its main product line, what is the firm's current market share?**

Answer: _____ %

5 **How many weeks ago did your firm change the price of the main product?**

Answer: _____ Weeks ago.

6 **Using the following frequencies, please identify how often this firm (formally) changes the price of its main product:**

(a) Daily

(b) Weekly

(c) Monthly

(d) Quarterly

(e) Half annually

(f) Annually

(g) Less frequently than annually

Section B. Manager Characteristics

7 **How many years of work experience do you have at this firm:** Answer: _____ years.

8 **What is your highest educational qualification?**

(a) Less than high school

(b) High school diploma

(c) Some college or Associate degree

(d) College Diploma

(e) Graduate Studies (Masters or PhD)

Section C. Macroeconomic Expectations

9 **What do you think will be the annual growth rate of real GDP in New Zealand in twelve months?**

Answer: _____ % per year.

10 **Could you provide us with an approximate range of what you think annualized real GDP growth in New Zealand will be over the next 12 months?**

Between _____ % per year (lowest forecast) and _____ % per year (highest forecast).

Section D. Predictions

11 **Over the next 3 months, by how much (in % changes relative to current level) do you expect to change:**

(a) The price of your main product: _____ %

(b) Investment in capital goods: _____ %

(c) Employment at your firm: _____ %

(d) Average wages: _____ %

Section E. Information Treatment

Group 0 (Control): No information. (300-400 pairs)

Group 1 (Mean treatment): We are going to give you information from a group of leading experts about the New Zealand economy. According to Consensus Economics, a leading professional forecaster, the average prediction among professional forecasters is that the real GDP will grow by XXX% in 2025. (300-400 pairs)

Group 2 (Uncertainty Treatment): We are going to give you information from a group of leading experts about the New Zealand economy. According to Consensus Economics, a leading professional forecaster, the difference between the lowest and highest predictions of real GDP growth is XXX percentage points for 2025. (300-400 pairs)

Allow for control and treatment according to two categories of firms.

i **Customer firm and their main supplier**

ii **Main supplier and their customer**

In (i), do not treat the main supplier firms.

In (ii), do not treat the customer firms.

12 **Please let me know what you perceive as the most pessimistic, the most likely, and most optimistic real GDP growth rate for New Zealand over the next 12 months. What do you think the lowest annualized real GDP growth rate might be for this time period, what do you think the most likely might be, and what do you think the highest might be? (please provide an answer as % per year).**

(a) Lowest real GDP growth rate:_____ % per year

(b) Most likely GDP growth rate:_____ % per year

(c) Highest real GDP growth rate:_____ % per year

Thank you very much for your participation.

Follow up Survey

NB: This survey is conducted approximately around 3 months after the first interview. Control group: appx 200 pairs. Treatment groups: appx 200 pairs for each group. Lower number of questions would really be beneficial in lifting up the responses in this followup wave.

Section A. Characteristics

1 **How many weeks ago did your firm change the price of main product?**
Answer: _____ Weeks ago.

Section B. Macroeconomic Expectations

2 **Please let me know what you perceive as the most pessimistic, the most likely, and most optimistic real GDP growth rate for New Zealand over the next 12 months. What do you think the lowest annualized real GDP growth rate might be for this time period, what do you think the most likely might be, and what do you think the highest might be? (please provide an answer as % per year).**

(a) Lowest real GDP growth rate:_____ % per year

(b) Most likely GDP growth rate:_____ % per year

(c) Highest real GDP growth rate:_____ % per year

Section C. Actions of firms

3 **Over the last 3 months, by how much (in % changes) did you change:**

(a) The price of your main product:_____ %

(b) Investment in capital goods:_____ %

(c) Employment at your firm:_____ %

(d) Average wages:_____ %

4 **What are the primary reasons behind your expectation of GDP growth and its range in question 2?**

Please select relevant options. Multiple answers are allowed.

(a) My customer/main supplier firm XXX changed fundamental factors (such as price, quantity, inputs), providing insights

(b) My customer/main supplier firm XXX directly shared information about GDP growth and uncertainty.

(c) Various other firms in your network changed fundamental factors or shared information.

(d) Public sources (such as government, central bank, news) of information.

(e) Other: Please specify _____

Section D. Supplier/Customer Characteristics

5 **What is your share of expenditure/sales to your customer/main supplier firm XXX?**

(a) Share of total expenditure: _____ % *If the respondent is a customer*

(b) Share of total sales:_____ % *If the respondent is the main supplier*

6 **In general, how often do you communicate with your customer/main supplier firm XXX?**

(a) About your product transactions

i Daily

ii Weekly

iii Monthly

iv Quarterly

v Semi-annually

vi Annually

vii Less frequently than annually

(b) About industry trends and conditions

i Daily

ii Weekly

iii Monthly

iv Quarterly

v Semi-annually

vi Annually

vii Less frequently than annually

(c) About economic trends and conditions

i Daily

ii Weekly

iii Monthly

iv Quarterly

v Semi-annually

vi Annually

vii Less frequently than annually

7 **In general, if you had to place a dollar value on the information that you acquire from your customer/main supplier firm XXX about product transactions, industry trends and conditions and economic trends and conditions each year, how much do you think that $ value would be? Please use minimum as $0 and maximum as $1000.**

(a) _____ $ per year for information on product transactions

(b) _____$ per year for information on industry trends and conditions

(c) _____$ per year for information on economic trends and conditions

Section E. Mechanisms for modeling

8 **What are the primary reasons you would share information about GDP growth and uncertainty with your customer/main supplier firm XXX?** *Multiple answers are allowed.*

(a) To reduce operational costs

(b) To comply with legal requirements

(c) To foster innovation and collaboration

(d) To gain a competitive advantage

(e) To foster trust

(f) To address common sectoral challenges

(g) I do not share information about GDP growth or uncertainty with my customer/main supplier firm XXX.

(h) Other: Please specify _____

9 **If you currently have a pricing and quantity contract with your customer/main supplier firm XXX, when was this contract initiated?**

(a) Less than 2 month

(b) 2-3 months

(c) 3-4 months

(d) Greater than 4 months

(e) No current contract

10 **Over the last three months, how many times did you communicate with your customer/main supplier firm XXX about GDP?** Answer: _____ times over the last three months.

Thank you very much for your participation.

C Proofs

C.1 Proof of Proposition 1

The current optimal price vector depends on current output, the current vector of signals, the current vector of ambiguity, and the vector of past prices. Hence, we guess the following solution:

$$\boldsymbol{p}_t = M_s \boldsymbol{s}_t + M_y \boldsymbol{y}_t + M_a \boldsymbol{a}_t + M_p \boldsymbol{p}_{t-1}$$

From here, expectations about the price vector in $t+1$ are given by

$$\widetilde{\mathbb{E}}_t \boldsymbol{p}_{t+1} = M_y \widetilde{\mathbb{E}}_t \boldsymbol{y}_{t+1} + M_p \boldsymbol{p}_t = -M_y \mathcal{C}(I-G)\boldsymbol{a}_t + M_y \mathcal{C} G \boldsymbol{s}_t + M_p \boldsymbol{p}_t$$

Hence,

$$\boldsymbol{p}_t = \Delta K \boldsymbol{y}_t + \Delta\Omega \boldsymbol{p}_{t-1} + \beta\Delta\Omega \left[-M_y \mathcal{C}(I-G)\boldsymbol{a}_t + M_y \mathcal{C} G \boldsymbol{s}_t + M_p \boldsymbol{p}_t\right]$$

where $K = diag(\boldsymbol{\kappa})$.

$$\boldsymbol{p}_t = (I - \beta\Delta\Omega M_p)^{-1} \left[\Delta\boldsymbol{\kappa} y_t + \Delta\Omega \boldsymbol{p}_{t-1} + \beta\Delta\Omega \left(-M_y \mathcal{C}(I-G)\boldsymbol{a}_t + M_y \mathcal{C} G \boldsymbol{s}_t\right)\right]$$

From here, it follows that

$$\begin{aligned} M_p - \beta\Delta\Omega M_p^2 &= \Delta\Omega \\ M_y &= (I - \beta\Delta\Omega M_p)^{-1}\Delta K \\ M_a &= -\beta(I - \beta\Delta\Omega M_p)^{-1}\Delta\Omega M_y\mathcal{C}(I - G) \\ M_s &= \beta(I - \beta\Delta\Omega M_p)^{-1}\Delta\Omega M_y\mathcal{C}G \end{aligned} \tag{16}$$

To solve for M_p, we rely on Theorem 3.5 in uhlig and to ensure that price dynamics are stable we only consider the solution for M_p whose eigenvalues are within the unit circle.

C.2 Proof of Proposition 2

Note that $\beta(I - \beta\Delta\Omega M_p)^{-1}\Delta\Omega M_y\mathcal{C}G = \beta M_p M_y\mathcal{C}G$, hence,

$$M_s = \beta \underbrace{M_p M_y}_{M}\mathcal{C}G = \beta \underbrace{\begin{bmatrix} M_{11} & M_{12} & ... & M_{1N} \\ M_{21} & M_{22} & ... & M_{2N} \\ ... & ... & ... & ... \\ M_{N1} & M_{N2} & ... & M_{NN} \end{bmatrix}}_{\text{standard IO component}} \times \underbrace{\begin{bmatrix} c_{11}G_{11} & c_{12}G_{22} & ... & c_{1N}G_{NN} \\ c_{21}G_{11} & c_{22}G_{22} & ... & c_{2N}G_{NN} \\ ... & ... & ... & ... \\ c_{N1}G_{11} & c_{N2}G_{22} & ... & c_{NN}G_{NN} \end{bmatrix}}_{\text{news processing and communication component}}$$

$$\frac{\partial \boldsymbol{p}_t}{\partial s_{jt}} = \beta \begin{bmatrix} M_{11} & M_{12} & ... & M_{1N} \\ M_{21} & M_{22} & ... & M_{2N} \\ ... & ... & ... & ... \\ M_{N1} & M_{N2} & ... & M_{NN} \end{bmatrix} \times \begin{bmatrix} c_{1j} \\ c_{2j} \\ ... \\ c_{Nj} \end{bmatrix} G_{jj} = \beta \begin{bmatrix} \sum_{k=1}^{N} M_{1k}c_{kj} \\ \sum_{k=1}^{N} M_{2k}c_{kj} \\ ... \\ \sum_{k=1}^{N} M_{Nk}c_{kj} \end{bmatrix} G_{jj} = \beta G_{jj} M\mathcal{C}_{:j}$$

To prove that all the elements of matrix M are positive, we first prove the following lemma:

LEMMA 1. *All the elements of matrix M_p are positive and less than unity, and the sum of elements in each row of M_p equals 1.*

PROOF. To prove the lemma above, we show that M_p and Ω share the same eigenvectors. Recall that M_p is the solution to the quadratic matrix equation: $M_p^2 - (\Omega^{-1}/\beta + I)\, M_p + I/\beta = \mathbf{0}_N$. Let

$$\Xi = \begin{bmatrix} \Xi_{11} & \Xi_{12} \\ \Xi_{21} & \Xi_{22} \end{bmatrix} = \begin{bmatrix} \Omega^{-1}/\beta + I & -I/\beta \\ I & \mathbf{0}_N \end{bmatrix}$$

Let λ be an eigenvalue of Ξ, then the eigenvector associated with it is the vector $X = \begin{bmatrix} X_1 & X_2 \end{bmatrix}'$, that is,

$$(\Xi - \lambda I)X = 0 \Rightarrow (\Xi_{11} - \lambda I)X_1 = X_2/\beta,\ X_1 = \lambda X_2$$

Hence, the eigenvector associated with λ is $X = \begin{bmatrix} \lambda X_2 & X_2 \end{bmatrix}'$. Therefore,

$$(\Xi_{11} - \lambda I)X_1 - X_2/\beta = 0 \iff (\Omega^{-1} - \underbrace{(\beta\lambda - \beta + 1/\lambda)}_{\text{e-value of } \Omega^{-1}} I)X_2 = 0$$

Uhlig (2001) shows that the eigenvector of M_p is given by X_2. Ω^{-1} and Ω share the same eigenvectors and, as a result, it follows that M_p and Ω also share the same eigenvectors. The largest eigenvalue of Ω is 1; the eigenvector associated with it is $e = \mathbf{1}_N$. It follows that e is also an eigenvector of M_p, hence $M_p e = e$ implying that the sum of each row of M equals 1 and that 1 is an eigenvalue of M_p. To guarantee a stable solution, it has to be that the remaining eigenvalues of M_p are within the unit circle. By the Gershgorin circle Theorem, each eigenvalue λ_i of M_p has to be within the following range $\left[1 - \sum_{j=1}^N m_{ij}^p - \sum_{j=1}^N |m_{ij}^p|, 1 - \sum_{j=1}^N m_{ij}^p + \sum_{j=1}^N |m_{ij}^p|\right]$. The bounds cannot exceed 1 or -1, implying that $\sum_{j=1}^N m_{ij}^p = \sum_{j=1}^N |m_{ij}^p|$, and that each element of M_p is positive. □

It is easy to see that $M_p M_y = M_p^2 \Omega^{-1} K$, where all the diagonal elements in K are positive. Since M_p and Ω^{-1} are stochastic matrices, it follows that $M_p^2\Omega^{-1}$ is also a stochastic matrix and that all the elements in M are positive.