ESSAYS ON AMBIGUITY, INFLATION AND INSTITUTIONS

MICHEL CÂNDIDO DE SOUZA

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Tese apresentada ao Programa de Pós-Graduação em Economia do Centro de Desenvolvimento e Planejamento Regional da Universidade Federal de Minas Gerais como requisito parcial para a obtenção do grau de Doutor em Economia.

ORIENTADOR: MAURO FERREIRA SAYAR
COORIENTADOR: LIZIA DE FIGUEIREDO

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MICHEL CÂNDIDO DE SOUZA

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Advisor: Mauro Ferreira Sayar
Co-Advisor: Lizia de Figueiredo

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BANCA EXAMINADORA

Prof. Mauro Sayar Ferreira
(Orientador) (CEDEPLAR/FACE/UFMG)

Profa. Lízia de Figueirêdo
(Coorientadora) (CEDEPLAR/FACE/UFMG)

Prof. Gilberto de Assis Libânio
(CEDEPLAR/FACE/UFMG)

Prof. Rodrigo Jardim Raad
(CEDEPLAR/FACE/UFMG)

Prof. Márcio Antônio Salvato
(IBMEC/MG)

Prof. Fábio Augusto Reis Gomes
(FEA-RP/USP)

Prof. Alexandre Mendes Cunha
Subcoordenador do Programa de Pós-Graduação em Economia

For my parents, my wife and my little boy

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Resumo

Esta tese é dividida em três ensaios independentes, os quais abordam os seguintes temas: ambiguidade, inflação e instituições. No primeiro ensaio, investigamos o comportamento da ambiguidade na economia brasileira, utilizando o arcabouço teórico/empírico apresentado por Izhakian(2017). Após construir uma série para captar ambiguidade agregada para a economia brasileira, são verificados os impactos de choques de ambiguidade no ciclo econômico doméstico através de VAR/SVAR. Choques adversos de ambiguidade causam forte redução na atividade econômica. No segundo ensaio, verificamos o comportamento assimétrico da curva de oferta agregada brasileira por meio de regressões quantílicas. As assimetrias resultam em diferenças na dispersão das distribuições da inflação condicionadas nas expectativas inflacionárias. Por fim, no terceiro ensaio, investigamos a influência de características históricas regionais, retratadas no Censo brasileiro de 1872, nas instituições atuais das mesmas localidades. Também verificamos essas influências no diferencial de renda das localidades estudadas através de regressões quantílicas em dois estágios. Os resultados sugerem que a qualidade institucional corrente é bastante correlacionada com as características observadas em 1872, afetando também a disparidade de renda per capita atual.

Palavras-chave: Ambiguidade, Inflação, Instituições.

Abstract

This thesis is developed in three independent essays, which address the following themes: ambiguity, inflation and institutions. In the first essay, we investigate the behaviour of ambiguity in the Brazilian economy, using the theoretical /empirical framework presented by Izhakian (2017). After constructing a series to capture aggregate ambiguity for the Brazilian economy, the impacts of ambiguity shocks on the domestic economic cycle are verified through VAR / SVAR. Adverse ambiguity shocks cause a sharp reduction in economic activity. In the second essay, we verified the asymmetric behaviour of the Brazilian aggregate supply curve through quantile regressions. The asymmetries result in differences in the dispersion of inflation distributions conditioned on inflationary expectations. Finally, in the third essay, we investigated the influence of regional historical features, reflected in the 1872 Brazilian census, on the current institutions of the same localities. Moreover, we also verified these influences on the income regional differences through two-stage quantile regressions. The results suggest that current institutional quality is strongly correlated with the characteristics observed in 1872, also affecting the current per capita income disparity.

Palavras-chave: Ambiguity, Inflation, Institutions.

List of Figures

List of Tables

Contents

Chapter 1

Ambiguity and Economic Cycles in Brazil

1.1 Introduction

Few papers seek to measure and empirically investigate the effects of ambiguity in economics. Much of the effort in this line of research uses data collected from experiments or proxies for ambiguity. Moreover, a dominant part of the literature directs efforts on the attitudes of individuals who are faced with ambiguity rather than on the implications of ambiguity itself, such as Anderson *et al.* (2009) and Antoniou, Harris and Zhang (2015). Basically, there is no study that derives a series to measure aggregate ambiguity and investigate its effects on macroeconomic variables. Specifically, in this essay, we seek to cover these gaps in the literature for the Brazilian case.

We follow the definitions of risk, ambiguity and uncertainty by Backus, Ferriere and Zin (2015). According to these authors, risk represents random situations in which the distribution of possible outcomes is known, ambiguity would be useful to describe situations in which some aspect of this distribution is unknown and uncertainty would be a higher state, which includes both risk and ambiguity.

Izhakian (2017) indicates that ambiguity, or *Knightian uncertainty*, represents cases in which, in addition to the final event being unknown, the probabilities of the events in the sample space are also unknown or are not defined exclusively. This ignorance about the probabilities is described by Dequech (2011) as the best refinement of the concept of ambiguity. We will follow this definition of Izhakian (2017) in the development of this essay.

For economic theory, according to Ellsberg (1961), every decision is subject to some level of ambiguity. Thus, in the same way that agents have aversion to risk, they also deal with aversion to ambiguity. Therefore, the level of ambiguity present in the economy can directly determine the decision-making process, generating significant effects on the economic cycles, as Backus, Ferriere and Zin (2015) point.

In the select group of papers that use historical stock price data, the main focus is on the estimation of predetermined aversion parameters through equilibrium models for microeconomic decisions, such as Williams (2015), Ulrich (2013) and Thimmea and Volkertb (2015). In the line of works that breaks this barrier, focusing mainly on the estimation of ambiguity and on the investigation of its effect, we have Izhakian and Yermack (2016) and Brenne and Izhakian (2018).

Izhakian and Yermack (2016) investigate the effect of ambiguity and risk on executive choices. These authors create ambiguity proxies per stock and show that each variable (risk and ambiguity) has a significant and independent effect on choices, when the employee stock options are executed[1]: Specifically, the risk leading executives keep the options longer and ambiguity increasing the tendency to execute the options ahead of the schedule.

Brenne and Izhakian (2018) analyse the relationship between risk, ambiguity and returns, proposing an ambiguity measure that is derived from stock market prices. The authors find that risk is positively related to returns, but ambiguity is negatively correlated. Moreover, the investor aversion to ambiguity is directly dependent on the probability of positive returns (for a fixed reference point). In addition to these evidences, the authors present a possible solution for the equity premium puzzle, suggesting that ambiguity is a missing factor.

For the Brazilian economy, there are no papers that analyze ambiguity, but the impact of aggregate uncertainty is analyzed by several researchers. Recently, two uncertainty variables have called attention: the economic policy uncertainty index (EPU) proposed by Baker, Bloom and Davis (2016) and the Brazil Economic Uncertainty Indicator (IIE-Br), calculated by the Brazilian Institute of Economics (IBRE) of the Fundacao Getulio Vargas. Both considering the frequency of uncertainty-related keywords in newspapers and magazines. Some examples are Pereira (2001), Silva Filho (2007),Costa Filho (2014), Souza, Zabot and Caetano (2017), Godeiro and Lima (2017) and Barboza and Zilberman (2018).

[1]Employee stock options give the employee (usually those in leadership positions) the right to buy stock at a pre-set price within a time frame.

Costa Filho (2014) indicates that a positive uncertainty shock produces a rapid and negative effect on the Brazilian economy. However, after the 2014 presidential elections, the series of uncertainty grew significantly in 2015 and 2016. According to Barboza and Zilberman (2018), this change negatively affected industrial production by 0.90 % to 3.90 %. These values were found from a SVAR model for the Brazilian economy.

Despite this concern with the impacts of uncertainty, non of these works try to evaluate uncertainty in a disaggregate manner. In this paper we analyze how ambiguity, which constitutes part of the uncertainty, affects the economy cycle. We conduct this analysis by first constructing an ambiguity index, through the Izhakian and Yermack (2016) theoretical model. This index is easily updated and can serve as an additional tool for monitoring the state of the economy.

Then, we introduce the estimated proxy in VAR/SVAR models. Our results indicate that ambiguity affects economic cycles. We can expect a decrease of approximately 0.60% to 1.10% for industrial production (between the second and the sixth months) and 0.25 % and 0.50 % for IBC-Br(between the second and the eighth months), after 1 standard deviation (0.013 in index values) positive shock in ambiguity. These responses are smaller than those reported by Costa Filho (2014) and Barboza and Zilberman (2018), following an aggregate uncertainty shock.

1.2 What is Ambiguity?

The separation between risk and uncertainty was pioneered by Knight (1921), as the distinction between the measurable and the immeasurable. Risk would be characterized by situations in which all possibilities are known and the probabilities of occurrence associated with the states can be precisely determined. Uncertainty would correspond to situations in which the possibilities and/or probability of occurrence of each state can not be determined with precision.

However, to better understand how uncertainty and ambiguity were introduced and differentiated, in economic theory, we must resort to some seminal works in the field of microeconomic decision theory: Von Neumann and Morgenstern (1944), Allais (1953), Savage (1954), Ellsberg (1961), Anscombe and Aumann (1963), Schmeidler (1989) and Gilboa and Schmeidler (1989). Besides these works, we also present the most recent advances in decision theory, which encompass attitudes under ambiguity: Tversky and Kahneman (1992), Ghirardato *et al.* (2004), Klibanoff *et al.* (2005) and finally Izhakian (2017).

1.2.1 Seminal Papers

Von Neumann and Morgenstern (1944) were responsible for the creation of the so-called Theory of Expected Utility. In this framework, for derivation of the expected utility that represents the individual preferences, four basic axioms are necessary: consequentialism, rationality, continuity and independence. Under this axioms we have the Von Neumann and Morgenstern (1944) Expected Utility Theorem. The expected utility equals the sum of the utilities of each state, weighted by the respective probabilities of occurrence (exogenous).However, this model has been severely criticized for treating uncertainty as risk through objective probabilities. In this work, there is no presence of individual beliefs and all agents know the probability distribution of events, considered well defined and unique.

As one of the first counterpoints, Allais (1953) demonstrates the possible unfolding of the certainty effect on individual choices, leading to contradictions in Von Neumann and Morgenstern (1944) axiom of independence. Allais (1953) emphasizes that agents tend to assign greater weight to events that are more likely to occur, which the author himself names as the *certainty effect*. Thus, in addition to constructing a direct critique on the independence axiom, Allais (1953) shows the relevance of uncertainty as a key factor in the decision-making process, since agents would tend to choose less uncertain situations for a variety of fixed returns. However,this study does not introduce this subjective component into the theoretical decision model.

In order to overcome the objective and exogenous probabilities, Savage (1954) attributed uniqueness to the utility ideas of agents and the perception of probabilities of states. Therefore, even sharing the maximizing behavior of the classical theory of expected utility, the subjective aspect is introduced considering that agents make different decisions due to their perceptions and utility functions.

The author postulates that individuals make decisions as if they formed their own probability distributions, based on their beliefs, which are used directly to maximize utility. Savage's theory provided the extraction of the subjective distribution of probabilities through the revealed preference relationships, making the utility function derivable.

Seven basic axioms are necessary to support the theorem: rationality, sure-thing Principle, independence of the ordinal event, comparative probability, non-degeneration, continuity of ,minor event (*archimedean*) and dominance. On these axioms, the Savage (1954) subjective expected utility theorem shows us that the agent has only one subjective probability vector and uses the expected utility in decision-making process. Instead of assuming the existence of predefined probabilities (objective and exogenous), in Savage

(1954) theory the individual probabilities would be derived according to the preference of the agents, subjectively.

However, all risk is identified as uncertainty, arising from subjective experiences, which makes the seminal concepts proposed by Knight (1921) inseparable within the theory of subjective expected utility developed by Savage (1954).

The first to challenge the theoretical implications of Savage (1954) work was Ellsberg (1961), who pondered the differences between risk, uncertainty, and ambiguity by retaking the concepts present in Knight (1921). Initially, through theoretical experiments, Ellsberg (1961) showed that in some cases the equality between risk and uncertainty could not be sustained.

In situations where there is uncertainty about probabilities (even with well-defined sample space), agents tend not to behave as described by Savage (1954), always preferring to make decisions in environments where probabilities are known than in environments where there is no complete clarity about probabilities, this postulate is also known as "*Ellsberg Paradox*".That is, regardless of the subjective probabilities formed by the individuals, in cases without complete certainty of the probabilities the individuals tend to choose the options with revealed probabilities. The term *ambiguity* was chosen to describe such situations where the axioms of the expected subjective utility theory would be insufficient and inadequate to predict decisions.

According to Ellsberg (1961), it is common to observe choices where agents violate the basic property of coherence, therefore the traditional models of choice would exclude simple situations of this kind. According to Ellsberg (1961), the violation of Savage (1954) postulate is related to ambiguity, defined as the quality, type, reliability and unanimity in the estimates of relative probabilities. Ambiguity represents the cases where, in addition to the final event being unknown (even with the clear alternatives), the probabilities of events present in the sample space are also unknown or not exclusively defined.

Ambiguity can still be understood as a situation that lies between two informational extremes: complete uncertainty and risk. In other words, risk represents random situations in which the distribution of possible outcomes is known. Ambiguity would be useful for describing situations in which some aspect of this distribution is unknown. Thus, uncertainty would be nothing more than a higher state, which includes both risk and ambiguity.

Starting from the recognition of this phenomenon, the literature began a process of development of theoretical models that could clearly separate the effects of risk and ambiguity, or that could accommodate the Ellsberg Paradox. In other words, the theoretical works started to seek a separation between preferences, when the probabilities of the sample space are well-defined, and individual convictions, when they are not.

As an initial advance between the contributions of Savage (1954) and Ellsberg (1961), we present the work of Anscombe and Aumann (1963), which involves the existence of multiple types of probabilities: some may be objective, such as the chance to get six in a dice roll, while others are specifically subjective, such as the possibility of your team being a world champion.

According to his formulation, the agent is indifferent about having prior knowledge or not of the state of nature. The decision maker subjectively believes that it is not possible to affect the objective probability of states.

Then, for the Anscombe and Aumann (1963) theorem, known as the Subjective Expected Utility (SEU), there is a subjective probability in determining the state of nature, but we also observe an objective probability in the choice of the exogenous distribution which represents the lottery of interest.

As pointed out, the work of Anscombe and Aumann (1963) presents an advance in relation to Savage (1954) and Ellsberg (1961), since it allows the coexistence of objective and subjective probabilities in the same model. However, the author still maintains an inseparable structure regarding uncertainty.

In the models exposed so far, all uncertainty has been quantified by additive probabilities. An important contribution to breaking this line is the work of Schmeidler (1989), based on the framework of Anscombe and Aumann (1963) and Choquet (1954) [2], which makes the first distinction between risk and ambiguity inside a theoretical model. This author works on the fact that probabilities necessarily represent individual beliefs, which can be captured with non-additive probabilities. In this new approach, a situation of uncertainty can be characterized by a set of events and their probabilities on a given subset, not exhausting 100% options.

Thus, using non-additive probabilities, Schmeidler (1989) incorporated into his work the aversion to ambiguity, consistent with the Ellsberg (1961) paradox and with the

[2] The Choquet integral allows integrating non-additive functions. For example, the output of an economics student can be measured by: mathematical knowledge, theoretical mastery, and writing quality. A standard case would be to assign weights to each of these characteristics, so that the sum is one. However, this situation can be complex, because the relevance of a set (mathematical knowledge; theoretical domain) would be equal to the sum of the weights. But if we look closely, a student with high mathematical knowledge and mastery of theory can develop works of greater impact. Others who only have a good theoretical mastery may not be able to execute projects with the necessary tools. Therefore, the combination between mathematical knowledge and theoretical domain would be fundamental, so that the relevance attributed to the individual who has both would be greater than the sum of the weights separately.

Anscombe and Aumann (1963) framework, through Choquet (1954) integral. The author relaxes Anscombe and Aumann (1963) independence axiom, replacing it with Comonotonic Independence.

Furthermore, the author introduces the concept of integral for non-additive probabilities. This theoretical approach is also widely known in the literature as Choquet Expected Utility (CEU). In this model, ambiguity aversion is introduced through convexity (non-additive probability) of preferences. In summary, the agent has his actions determined by a set of probabilities, and his utility is calculated as the minimum among the probabilities represented by *core(v)*. Therefore, this extension proposed by Schmeidler (1989) accommodates the Ellsberg (1961) paradox.

Still in the field of models that sought to incorporate the Ellsberg (1961) paradox, distinguishing the risk of uncertainty, we highlight the model of Gilboa and Schmeidler (1989). Through more flexible axioms, the authors deal with the preferences of the agents in environments with ambiguity, that is, in situations where there is more than one probability in the occurrence of each event. Here, it is important to mention an expressive advance in the literature, where ambiguity can be understood not only in terms of aversion, but also in level.

Following the framework of Anscombe and Aumann (1963), the authors maintain the axioms of weak order, continuity, monotonicity and non-degeneration, and include two new axioms: certainty independence and ambiguity aversion. The set of probabilities represents the "*beliefs*" of the agent, which indirectly reflects the level of ambiguity, since this set represents a collection of probabilities for each event. The ambiguity aversion is understood as a process of minimization, since the individual acts as a pessimist in the utility maximization process, behaving according to the worst probability option.

In the framework of non-additive subjective probabilities, we also have Tversky and Kahneman (1992) cumulative perspectives theory, which focuses on taste analysis of decision makers.It is worth emphasizing that the approach is adequate to deal with both Allais (1953) and Ellsberg (1961) paradoxes. According to Tversky and Kahneman (1992) non-additive subjective probabilities in uncertain environments, would have asymmetric weighting schemes as to the possibilities of losses and gains. One of the main contributions of this theory is about the framing of rewards as gains or losses relative to a reference point, not a final state of wealth.

Asymmetry does not occur directly on probabilities, this distortion is given by the channel of the cumulative distribution function. Basically, the weight of a result depends exclusively on the location of this result among the space of alternatives in the cumulative distribution.

Furthermore, the Tversky and Kahneman (1992) model determines that the weight of each decision is formed from the cumulative distribution. All possible returns (positive or negative), coming from the choices, are increasingly ordered in terms of preferences. Synthetically, author indicate that in decision process, under uncertainty, not only the amount of uncertainty matters (detected by the value function) but also the source of this uncertainty, variant according to the weight of decisions.

However, even with the incorporation of the Ellsberg (1961) paradox, and considering the separation between risk and uncertainty, the CPT model does not advance in the dissociation of *tastes* and *beliefs*. Later, Fox and Tversky (1995) insert the possibility of susceptibility to uncertainty in environments of comparative competence. Basically, they extend the model to situations of optimism, where in addition to considering probabilities directly, agents prefer to make choices in situations that feel competent rather than in opposing situations.

Advancing in the unified embodiment of optimistic and pessimistic behaviors, Ghirardato *et al.* (2004) introduce a separation of tastes and beliefs, based on the theoretical framework of Gilboa and Schmeidler (1989) and on Hurwicz (1951) criterion.

With the exception of the ambiguity aversion axiom, the authors adopt the same axiomatic representation of the MEU model and include a specific preference format (α-MEU Preferences).Under these axioms, there is no assumption about the aversion or propensity to ambiguity in this model. In fact, the agent reveals his preferences from a mix of behaviors, given by the operators *max* and *min*. In addition, the set of probabilities represents the *beliefs* of the agent, indirectly reflecting the level of ambiguity. Finally, the model can converges to the standard MEU and to the MaxMax situations, where there is predisposition to uncertainty environments according to the quality of the information available.

Before presenting the most recent advance on the uncertainty decision theory, we highlight a relevant model regarding the treatment of ambiguity in decision theory, the smooth ambiguity model by Klibanoff *et al.* (2005).

The authors indicate that the $\alpha - MEU$ model is very basic for a refined application of the Hurwicz (1951) criterion, since the axioms are satisfied only when the agent considers the extremes of expected utility (infimun and supremum) as priors. In other words, although the acts are evaluated as a convex combination of extremes, the optimal choice rule does not consider the intermediate values.

To overcome this deficiency, Klibanoff *et al.* (2005) suggest the substitution of the Hurwicz (1951) criterion by an aggregation of the whole set of possible expected utilities on the set of priors, leading to a second order probability representation. Furthermore, uncertainty is introduced non-linearly in the utility function, which allows the capture of non-neutral attitudes under ambiguity.

The theory has an external utility function, which characterizes attitudes of ambiguity over the set of priors, and an internal utility function (Von Neumann Morgenstern type) which characterizes attitudes of risk in the decision-making process. Respecting some definitions and assumptions, Klibanoff *et al.* (2005) theorem state that an increase in ambiguity occurs through an indirect increase in the range of the subjective priors and reflects the level of ambiguity present in the agent's decision, and not only the risk and aversion to ambiguity.

In more recent works, we highlight the contributions of Backus, Ferriere and Zin (2015) and Bianchi,Ilut and Schneider (2018). These authors seek to identify and define the propagation mechanisms of ambiguity aversion shocks. The shocks represent fluctuations in beliefs of worse scenarios in a given period of time. In other words, the literature (mostly focused on DSGE models) expresses the ambiguity shocks as an additional pessimism in worst-case situations.

Based on the Klibanoff *et al.* (2005) model (smooth ambiguity), Backus, Ferriere and Zin (2015) introduce aggregate uncertainty (risk and ambiguity) in an RBC model, seeking to understand the magnitude and persistence of the last recessions. The results of the simulated model indicate that ambiguity has a greater effect on prices than on quantities produced. In addition, the more the parameter of aversion varies over time, the greater the effects of recessive shock. However, the effects are not large enough to explain the latest recessions. The authors conclude that uncertainty is not irrelevant to business cycles, but the mechanism that produces greater impact must operate through other channels.

Bianchi,Ilut and Schneider (2018) construct a DSGE model with endogenous financial asset supply and ambiguity averse investors. The authors model the aversion to ambiguity by the multiple priors of belief formation. So when investors need to deal with future consumption planning, they often use the worst-case probability. After estimating the system of equations, some results call attention: i) regime shifts in volatility help understand macro quantities and low frequency movements in asset prices. ii) Financial quantities depend relatively more on uncertainty shocks than real variables.

However, even improving the separation between risk and ambiguity, the authors still maintain some relation between these factors, mainly due to the completeness of the functions, which does not allow a direct empirical application of the model.

1.2.2 Expected Utility with Uncertainty Probabilities Theory

Izhakian (2017) seeks to overcome the limitations of the Klibanoff *et al.* (2005) model, presenting a framework of decisions under ambiguity through uncertain probabilities. The author presents a model that advances in the distinction between ambiguity and risk in uncertainty environments. The separation proposed by the author refines the separability of the concepts and advances in one of the main gaps of the literature: the empirical application.

The intuition of this model is that preferences under ambiguity are applied directly to the initial set of probability distributions (priors). Ambiguity aversion is defined as aversion to the preservation of the mean in the set of probabilities, but the level of ambiguity is measured similarly to risk in the financial literature: the author proposes that ambiguity can be represented by the variance of the probabilities related to the same event, in the set of densities. And it is from this measure that the empirical applicability of the model is possible.

Briefly, we will outline the theoretical bases of Izhakian (2017). Decision making is divided into two stages: i- Probability formation phase: first, the agent forms a representation of his probability perceptions for all events of interest. ii- The valuation phase: in this second moment, the agent evaluates each option using the set of probabilities, formed in the first step, and makes the decision. Thus, in this framework, a complete distinction between risk and ambiguity occurs, since ambiguity affects the first moment of decision making, while risk directly affects the second phase. It's important to note that these two phases of the decision-making process are modelled in two separate state spaces.

On the first space, the authors adopt some fundamental hypotheses: i) S is an infinite state space (also named as the first state), endowed with a $\sigma - algebra$. ii) The generic elements of this algebra are called events and are indicated by E. iii) $\lambda - system$, $H \subset \varepsilon$ should be thought of as containing events with unambiguous probability. In other words, these events can be considered events with a known and objective probability, according to all possible measures.

Considering now a finite non-empty state space (second space) P^*, and $X : S \to \mathbb{R}$ a function that describes the investment payoff. A decision maker who does not know precisely the probabilities associated with each possible result holds a set of possible additive probability measures, from P to S. In addition, the agent maintains a set of second-order beliefs (or a measure of probability on P^*) denoted by ξ. Izhakian (2017) postulates that, based on his EUUP proposal, the expected utility of an agent that does not distort its probabilities can be perceived as:

$$V(X) = \int_{z\leq 0}\left[\Upsilon^{-1}\left(\int_{P^*}\Upsilon(P(U(x)\geq z))d\xi\right)-1\right]dz + \int_{z\geq 0}\left[\Upsilon^{-1}\left(\int_{P^*}\Upsilon(P(U(x)\geq z))d\xi\right)\right]dz \tag{1.1}$$

Let X be the investment payoff, U be a Von Neumann-Morgenstern utility function and Υ a function that measures the agent's perspective, or in other words, that capture attitudes under ambiguity situations [3].Also, the utility function is normalized by z and, for a reference value k, $U(k) = 0$. This point k is a reference for the decision maker, since realizations below (above) it are considered losses (gains)[4]. In this model, the risk and ambiguity preferences are formed, respectively, by the functions U and Υ. In addition, the uncertain probability measure,P, represents the first-order beliefs and ξ indicates the second-order beliefs.

Basically, in the probability formation phase, the perceived probabilities are constructed through a Bayesian framework, using the certainty equivalent of uncertain probabilities. Through this structure, a complete distinction between risk and ambiguity occurs, since they are measured in different spaces. In other words, for the Bayesian approach, it is essential that the unknown be properly modeled in a state space, subject to prior probabilities. The last equation (1.1), through a Choquet integration, represents a complete distinction between risk and ambiguity in the agent's decision-making process.

For the empirical application, following Izhakian (2017), the expected utility theorem with uncertain probabilities can be rewritten as:

$$W(X) = \int_{x\leq k} U(x)E[\varphi(x)]\left(1-\frac{\Upsilon''(1-E[P(x)])}{\Upsilon'(1-E[P(x)])}Var[\varphi(x)]\right)dx + \tag{1.2}$$
$$\int_{x\geq k} U(x)E[\varphi(x)]\left(1+\frac{\Upsilon''(1-E[P(x)])}{\Upsilon'(1-E[P(x)])}Var[\varphi(x)]\right)dx$$

[3]We emphasize here that the concavity pattern is the same for two functions: thus, concave represent attitudes of aversion and convex represent the propensity.

[4]In other words, considering that zero is obtained when $U(x = k) = 0$, the integral is executed in two possibilities, when the normalized utility is above the reference point (gains) and when it is below (losses).If we observe $z \geq 0$, we have that return $x \geq k$.

where $P(x)$ is a cumulative probability of x; $\varphi(x)$ is the probability density function (or probability mass function in discrete state space) associated with P.

Ambiguity takes the form of perturbations of probability and aversion to ambiguity. The previous theorem proves that, given two identical acts, except in the degree of ambiguity, any ambiguity-averse decision maker prefers the act with the lowest $\mho^2$, or the act whose associated probabilities are, on average, less volatile.

In summary, $\mho^2$ aggregates the variances of probabilities, which measure the dispersions of the probabilities of each result, while assigning to the variance of each probability a weight equal to the expected probability. Thus, according to Izhakian and Yermack (2016), $\mho^2$ can be rewritten as the expected volatility.:

$$\mho^2[x] = \int E[\varphi(x)]Var[\varphi(x)]dx \tag{1.3}$$

One of the greatest advances in ambiguity estimation, proposed by Izhakian and Yermack (2016), is about *stake independence*. This property of $\mho^2$ makes the measure independent of risk, i.e., the analysis of variance in the probabilities of priors is independent of the risk degree. In other words, for any event, the degree of ambiguity is invariant to the consequence of this event. As an example, given a set of N possible returns of an action r_j, with $j = 1, 2, ..., N$, and the set of probabilities for each return j given by C_j, the property of independence tells us that for any transformation $k(r_j)$, where k is a constant, we have that the set C_j does not change.

Briefly, Izhakian and Yermack (2016) use data from a variety of assets traded on the stock exchange, at intervals of five minutes between 9:30 and 16:00, giving 79 prices in total for each day. For the execution of time series tests, the author emphasizes the need for monthly aggregated data. To obtain a monthly indicator for ambiguity, Izhakian and Yermack (2016) constructs daily estimates for the probability distributions (using five minutes data).

After estimating the daily densities, the author calculates the mean and standard deviation of each day, considering all the densities of each month as the monthly set of priors of the agents. Furthermore, for the empirical application based on the $\mho^2$ formula, the authors impose that the returns must be normally distributed and that the ambiguity is estimated by asset.

Subsequently, Izhakian and Yermack (2016) divides the daily returns of each distribution from -10% to $+10\%$, totalling 40 bins per day, each with a width of 0.5%. After this division, for each day, the author calculates the probability of the return being in each bin. Finally, using these probabilities, the author calculates the mean and the variance for each of the 40 bins separately, within each month. Then, Izhakian and Yermack (2016) estimate the degree of ambiguity of each month by asset:

$$\mho^2 = \frac{1}{wln\left(\frac{1}{w}\right)}\left(E\left[\Phi(r_0;\mu,\sigma)\right]Var\left[\Phi(r_0;\mu,\sigma)\right] + \right. \tag{1.4}$$
$$\sum_{i=1}^{40} E\left[\Phi(r_i;\mu,\sigma) - \Phi(r_{i-1};\mu,\sigma)\right]Var\left[\Phi(r_i;\mu,\sigma) - \Phi(r_{i-1};\mu,\sigma)\right] +$$
$$\left. E\left[1 - \Phi(r_{40};\mu,\sigma)\right]Var\left[1 - \Phi(r_{40};\mu,\sigma)\right]\right)$$

Where Φ represents the distribution of probabilities by interval, r_i represents the returns, μ the average of the probabilities inside the bin and σ the respective standard deviation. Furthermore, $r_0 = 0.10$, $w = r_i - r_{i-1} = 0.005$, and $\frac{1}{wln\left(\frac{1}{w}\right)}$ scales the weighted-average volatilities of probabilities to the bin's size [5].

Izhakian and Yermack (2016) uses return-by-minute data when estimating ambiguity per asset. The author assumes that the daily distribution of probabilities of the returns follows a log-normal model. Then, the set of distributions within one month represents the agent's priors and the variance of the probabilities of each asset, based on percentage point deviations from the mean, is transformed into a monthly series of ambiguity.

Since we do not have data per minute, we use daily data to generate several portfolios to obtain the distribution of daily return. We follow Izhakian and Yermack (2016) proposal to measure ambiguity (variance of probabilities within one month), but we overcome the hypothesis of normal distribution for daily returns, testing some variants. In other words, the main methodological difference of this assay is as to the process generating the density functions per day. Furthermore, after the estimation, we advance in understanding the effects of ambiguity on business cycles, through VAR/SVAR models.

1.2.3 Uncertainty: Empirical Studies in Brazil

Recently, the Central Bank of Brazil highlighted the possible impacts of the level of uncertainty in the country: *"the long-term maintenance of high levels of uncertainty about the evolution of the process of reforms and adjustments in the economy can have a negative*

[5]This scaling is the same as Sheppard's correction, it minimizes the effect of the selected bin size on the values

impact on economic activity'[6]. The statement also makes clear that the Monetary Policy Committee (COPOM) conditional projections for that time involved a greater degree of uncertainty.

There are no studies that seek to investigate the effects of uncertainty in a disaggregated way (risk and ambiguity) for Brazil. However, we briefly highlight some recent studies that, even dealing with the uncertainty component in an aggregate way, contributed to the understanding of the effects of this variable on the Brazilian economy: Pereira (2001), Silva Filho (2007),Costa Filho (2014), Souza, Zabot and Caetano (2017), Godeiro and Lima (2017) and Barboza and Zilberman (2018).

Pereira (2001) considers a model of adjustment costs to analyze the relationship between uncertainty and investment. As a measure of uncertainty, the author considers the average of the conditional variances of the series of interest rate, real exchange rate and capital goods prices, estimated from a GARCH(1,1) model. The estimated results for the period between the first quarter of 1980 and the fourth quarter of 1998 indicate that investment is negatively affected by uncertainty in the long term.

Silva Filho (2007) assesses the relationship between inflationary uncertainty and investment for the economy in the period between 1974 and 2002, finding negative effects on the country's investment in the short and long term.

Costa Filho (2014) estimates several bivariate VAR's and investigates possible effects of various measures of uncertainty on economic activity in Brazil. The author finds that a positive shock in uncertainty produces negative and rapid effects on the Brazilian economy when compared to interest rate shocks.

Souza, Zabot and Caetano (2017) investigate the dynamics and transition of uncertainty in Brazil using quantile auto regression (QAR). The results reveal asymmetric dynamic along different conditional quantiles, corroborated by the analysis of dispersion, amplitude and densities. Furthermore, it is suggested that there is a low or even null probability of migration from a high to a low level of uncertainty condition and vice versa.

Godeiro and Lima (2017),following the methodology proposed by Jurado (2015), construct an index of macroeconomic uncertainty for Brazil and demonstrate that periods of recession are preceded by an increase in uncertainty. Furthermore, there is evidence of a negative correlation between macroeconomic uncertainty and industrial production.

Finally, Barboza and Zilberman (2018) construct an SVAR model following Baker, Bloom and Davis (2016). The authors diversify the presence of several measures of uncer-

[6]Notes from the 207th Meeting of the Monetary Policy Committee (COPOM) of the Central Bank of Brazil - May 30 and 31, 2017

tainty and economic activity, finding that the effects of uncertainty on economic activity are always negative and significant, with an average duration of 6 months.

These results show the relevance of uncertainty for determining Brazilian macroeconomic variables. In the next section, we go a step further and evaluate the impact of ambiguity alone in the business cycle. But first we need to construct a variable able to proxy for ambiguity.

1.3 Measuring Ambiguity

1.3.1 Proxy Estimation

We follow the work of Brenne and Izhakian (2018), which applies the methodology of Izhakian and Yermack (2016). First, the authors assume that daily returns (considering the data set per minute, between 9:30 and 16:00) follow a log normal distribution and then form a daily distribution with 40 bins. Because we do not have access to per-minute data for most of the sample, we use 16 portfolio returns to build the daily distribution. Specifically, instead of considering the data set per minute as the elements of the daily distribution, we obtain the daily distribution by considering the daily return of 16 different portfolios.

The construction of the portfolios follow Fama and French (2015). Every year we separate assets (traded on the Ibovespa) into sixteen portfolios, according to: i) Size,Sz: based on the market value (MV) at end of June of the current year, to ensure that the data in the financial statements of the previous year have already been officially disclosed, avoiding the look-ahead bias[7] .ii) Book-to-Market index,BM: the proportion between the Book Equity(BE) and Market Value (MV) of the company at the end of December of the previous year. iii) Operating-Profitability index,OP: the relationship between Earning Before Interest and Taxes ($EBIT$) and the Book Equity(BE), at the end of December of the previous year. Finally, iv) Investment index, Inv: the ratio between the variation of Total Assets TA(t-1 and t-2) and the level of Total Assets at the end of December of t-2.

Portfolios are separated as follows: at the end of June of each year, we divide all assets into two groups: below S(Small) and above B(Big) the median of Sz index. The next steps follow the same logic (subgroups divided from the median), resulting in a total of 2^4 different portfolios.The second subgroup is BM, divided into H(High) or L(Low),

[7]This bias occurs when there is the use of information after the date of sample collection.

the third is OP group between R(Robust) or W(Weak), and the fourth is Inv group, C(Conservative) or A(Aggressive). Each portfolio is constructed by the four initials of the subgroups that it belongs to, for example: a portfolio that Sz is S (Small), BM is H (High), OP is R (Robust) and Inv is C (Conservative) is named as $SHRC$. The daily return of each stock is given by $R_t = ln(\frac{P_t}{P_{t-1}})$ and the portfolio return is calculated according to the proportion of the market value of each stock in that specific portfolio. After calculating portfolio daily returns, as previously mentioned, we build the daily distribution (initially defined as log normal).

We next follow Izhakian and Yermack (2016) who show that ambiguity can be captured by the variance of probabilities. After the construction of density functions, each day, we define standard bins to be applied to all densities. We use Interbank Deposit Certificate (CDI) returns as a reference point and select the area from -10% to $+10\%$ around the reference point and split the distribution in 0.5% intervals. From these bins we calculate the probabilities through the area below the curve (definite integral) in the respective interval that delimits the bin. Specifically, the intervals are similar for every day (percentage changes on return of the risk-free asset), but as the moments of portfolio returns distribution change over these days, their probabilities change. Finally, we measure the total variation of probabilities in each bin within a month, weighted by the expected probability, using equation (1.6).

1.3.2 Does Ambiguity Affects Economic Cycles?

In order to verify if ambiguity influences the economic cycle, we use vector autorregresion (VAR). Consider the following system consisting of two structural equations:

$$y_{1,t} = \beta_{10} - \beta_{12} y_{2,t} + \theta_{11} y_{1,t-1} + \theta_{12} y_{2,t-1} + \epsilon_{y1t} \tag{1.5}$$

$$y_{2,t} = \beta_{20} - \beta_{21} y_{1,t} + \theta_{21} y_{1,t-1} + \theta_{22} y_{2,t-1} + \epsilon_{y2t} \tag{1.6}$$

The problem in estimating the previous system is that the contemporary variables $y_{2,t}$ and $y_{1,t}$ are correlated with the error terms ϵ_{y1t} and ϵ_{y2t} respectively. Thus, such correlation violates the assumption of exogeneity required for the estimation. But we can transform this system in a reduced form for estimation purposes and and then use identification strategies to recover the structural model. To start, let's represent the system in a matricial form:

$$BY_t = C_0 + C_1 Y_{t-1} + U_t \tag{1.7}$$

Where Y_t represents a vector of endogenous variables, B is a matrix of contemporary effects, C_0 is a vector of constants, C_1 is the parameter matrix and U_t the vector of errors.

The VAR in reduced form can be written as:

$$Y_t = A_0 + A_1 Y_{t-1} + E_t \tag{1.8}$$

Where Y_t represents a vector of endogenous variables, A_0 is a vector of constants, A_1 is the parameter matrix and E_t the vector of errors.

The problem in recovering the $SVAR$ model from a reduced VAR is the system identification, since the number of parameters does not match in the complete models. As an example: there are 9 parameters estimated in the reduced $VAR(1)$ model, for 10 parameters that need to be recovered in the $SVAR$ model. Then, according to Sims (1986), to identify the structural model from an estimated VAR, we need to impose $\frac{n(n-1)}{2}$ restriction in the contemporary matrix B.

1.3.3 Data

1.3.3.1 Ambiguity Proxy

To estimate the ambiguity proxy, we work with all stocks traded in the São Paulo Stock Exchange (BOVESPA) from July 2000 to June 2016. Since we do not have data per minute, we use daily data and portfolio analysis to generate the density of returns. All variables used in the construction of the model were taken from Economatica Software. Initially, following what is proposed by Fama and French (1993), we exclude from the sample:

1- Financial firms, since according to Fama and French (1993) the high level of debt in this sector distorts the Book-to-Market index and may compromise the results;

2- Stocks that did not present consecutive daily quotations in the previous 18 months and in the 12 months after the portfolio formation period. Here, the previous 18 months are fundamental to obtain the Inv. The post 12 months help in the calculation of stock returns;

3- Companies with no market value on December 31 and June 30 of each year, with tolerance of 21 days;

4 - Stocks that did not present positive Net Worth and/or Total Assets on December 31 of each year;

5- Companies that have not listed in at least 50% of the trading sessions each year;

6- Finally, in order to avoid distortions in the calculation of factors, for companies that own ON and PN shares, the market value was considered as the sum of these categories.

Each stock return is computed according to $R_t = ln(\frac{P_t}{P_{t-1}})$ and the portfolio return is calculated by the weighted average, using market value.

1.3.3.2 VAR Analysis

The data used in the VAR model, with monthly frequency, are the following:

Table 1.1: Variables

Name	Source	Code	Time
Employment	IBGE	EMP	2003:01-2016:02
Industrial Production	IBGE	INDP	2003:01-2016:02
IBC-Br	Central Bank of Brazil	IBC	2003:01-2016:02
Price Index	Central Bank of Brazil	IPCA	2003:01-2016:02
Exchange Rate	Central Bank of Brazil	EXCH	2003:01-2016:02
Interest Rate	Central Bank of Brazil	SELIC	2003:01-2016:02
Ibovespa Volatility	IPEADATA	VL	2003:01-2016:02
Embi	Chile Bank	EMBI	2003:01-2016:02
Proxy Ambiguity	Estimated	AMB	2003:01-2016:02

Note: Database, with time periodicity, code and source.

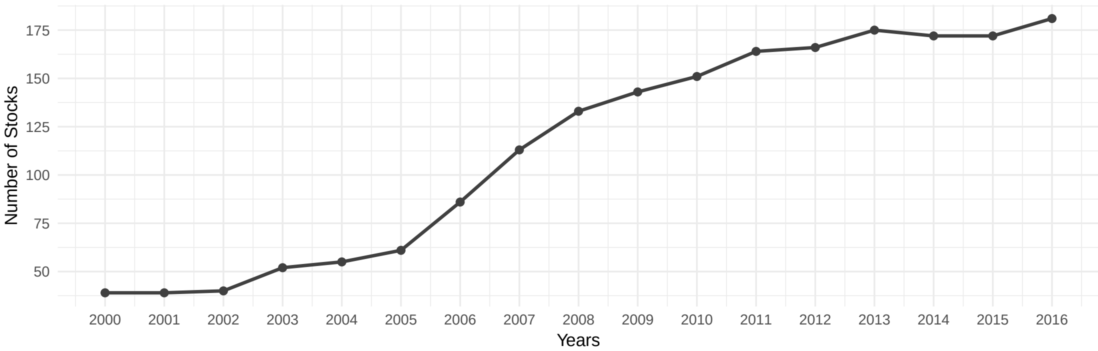
We use data from the Brazilian Central Bank, Brazilian Institute of Geography and Statistics (IBGE), Institute of Applied Economic Research (Ipea) and Bank of Chile. In addition, we worked from 2003 to 2016, due to the availability of the series of interest.

1.4 Results

1.4.1 Separation of Portfolios

After the exclusions, we work with the following number of assets per year:

Figure 1.1: Years x Number of Stocks



Note: Total number of assets used to build the portfolios in each year.

We can see that the number of eligible assets in the database grows over the years, which is expected due to the development of $BM\&BOVESPA$. For a better understanding of the database, and the companies used in the estimation, we present the set of assets, by portfolio, each year:

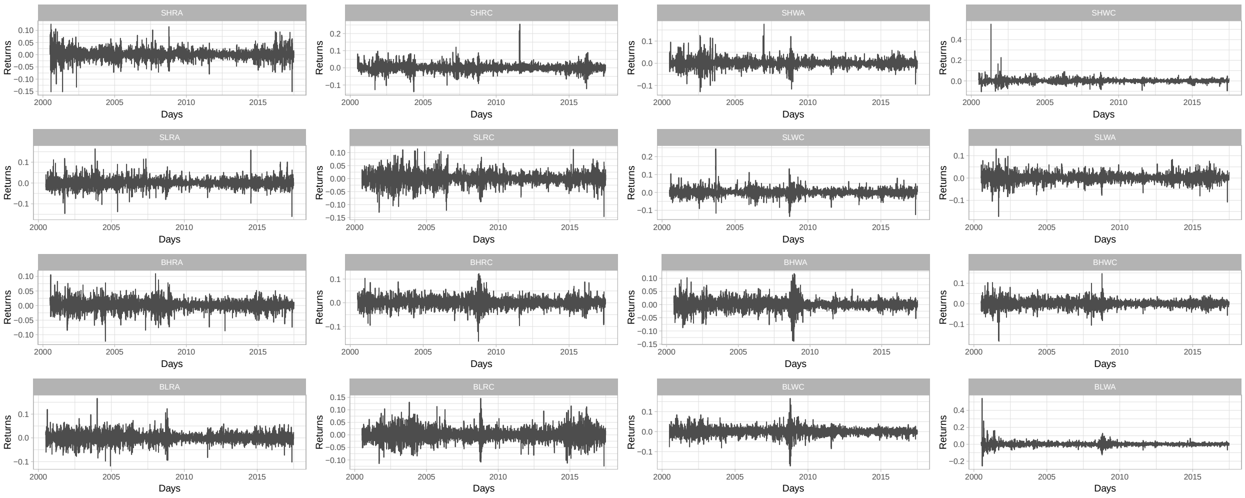
Table 1.2: Total Number of Assets by Portfolio in each Year.

Portf.	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
SHRC	2	2	2	3	2	3	5	7	8	8	9	10	9	10	10	10	11
SHRA	3	3	3	3	5	4	5	7	8	9	10	10	11	11	11	11	12
SHWC	2	2	2	3	3	3	4	6	9	9	8	10	11	11	11	11	11
SHWA	3	3	3	4	4	4	7	8	9	10	11	11	11	11	11	11	12
SLRC	2	2	1	3	3	4	5	7	8	9	9	9	10	11	10	10	11
SLRA	3	3	4	3	4	4	6	7	9	9	10	12	11	11	11	11	12
SLWC	3	2	2	3	3	3	5	7	8	9	9	10	10	11	11	11	12
SLWA	3	3	3	4	4	6	6	8	9	9	10	11	11	12	11	11	12
BHRC	2	2	2	2	2	3	3	6	7	8	8	8	9	10	10	9	10
BHRA	2	2	3	3	4	3	6	8	8	9	9	11	11	10	11	12	11
BHWC	2	1	2	4	3	4	5	7	8	9	10	10	10	11	11	10	11
BHWA	2	4	3	4	4	5	6	7	8	9	10	10	11	12	11	11	12
BLRC	2	2	2	2	3	2	5	5	8	9	8	10	10	10	9	11	11
BLRA	2	2	3	3	3	5	6	8	9	9	10	11	10	12	11	11	11
BLWC	2	3	2	3	4	4	6	7	8	9	10	10	10	10	11	11	11
BLWA	4	3	3	5	4	4	6	8	9	9	10	11	11	12	12	11	11
Total	**39**	**39**	**40**	**52**	**55**	**61**	**86**	**113**	**133**	**143**	**151**	**164**	**166**	**175**	**172**	**172**	**181**

Note: Portfolios Distribution. The acronyms of the portfolios were presented in topic 1.3.1.

Figure 1.2 shows the daily returns of the portfolios and table 1.3 presents the descriptive statistics:

Figure 1.2: Portfolios Returns



Note: Daily portfolio returns.

Table 1.3: Portfolios Statistics

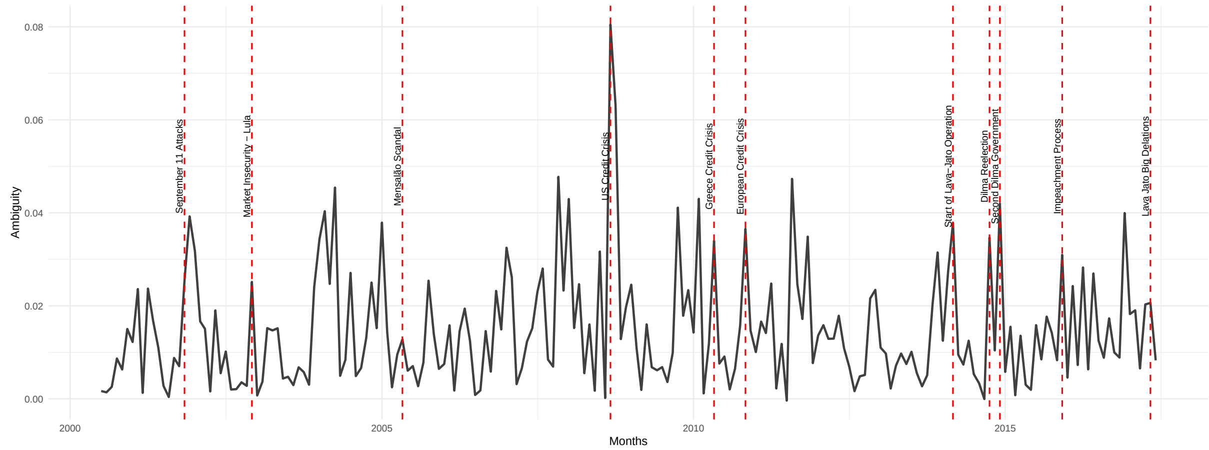
Portfolios	Mean	Median	Variation	Asymmetry	Kurtosis
SHRC	0.00072	0.00000	0.00041	0.10668	12.37310
SHRA	0.00072	0.00000	0.00039	0.10922	6.52964
SHWC	0.00058	0.00000	0.00036	0.09148	164.36887
SHWA	0.00093	0.00000	0.00031	0.15870	9.64493
SLRC	0.00012	0.00000	0.00047	0.01719	3.86611
SLRA	0.00001	0.00000	0.00044	0.00214	6.16303
SLWC	0.00076	0.00000	0.00036	0.11943	13.41892
SLWA	0.00045	0.00000	0.00032	0.07535	5.50176
BHRC	0.00019	0.00000	0.00040	0.02922	4.28800
BHRA	0.00073	0.00019	0.00030	0.09351	3.61617
BHWC	0.00049	0.00000	0.00032	0.08226	9.26900
BHWA	0.00019	0.00000	0.00033	0.03115	6.58421
BLRC	0.00004	0.00000	0.00059	0.00453	2.67021
BLRA	0.00038	0.00000	0.00041	0.05625	3.59753
BLWC	0.00001	0.00000	0.00036	0.00204	8.62866
BLWA	0.00055	0.00000	0.00048	0.07489	101.36248

Note: Descriptive statistics.

1.4.2 The evolution of the ambiguity index in Brazil

In this section we present the time series of estimated ambiguity and try to verify the coincidence between periods of high ambiguity and historical facts. In the following Figure the ambiguity is presented. The gray line is the level and the respective historical moments are represented by the orange dotted line:

Figure 1.3: Ambiguity



Note: Ambiguity proxy and historical events.

The series has an average of 0.012, median 0.011 and standard deviation 0.013. It has a positive asymmetry of 0.641, indicating that the values are concentrated to the right of the distribution. Finally, the kurtosis of 4.412 suggests a fat tail pattern.

Table 1.4: Ambiguity - Statistics

	Mean	**Median**	**Std Deviation**	**Asymmetry**	**Kurtosis**
AMB_t	0.012	0.011	0.013	0.641	4.102

Note: Ambiguity proxy descriptive statistics.

The first, second and third order autocorrelation coefficients of the series, all around 0.13, also indicates a stationary index. In this case, there are strong indications that the series is stationary, which can be confirmed by the standard unit root tests.

Table 1.5: Ambiguity - Autocorrelations

	AMB_{t-1}	AMB_{t-2}	AMB_{t-3}
AMB_t	0.142	0.136	0.100

Note: Ambiguity proxy autocorrelations.

Analyzing the series, we observe an increase on September 11th coinciding with September 11, 2001. Earlier that day, terrorists intentionally crashed two planes into the Twin Towers of the World Trade Center complex in New York City, killing everyone on board and many of the people working in the buildings. This attack generated a state of calamity throughout the world, initially due to great insecurity regarding other possible attacks and indirectly by the probability of the episode culminate in a great war in the Middle East.

Between August 2002 and April 2003 there are periods of peaks in the ambiguity series. This fact occurs by the presidential election. The winner (Lula) was confirmed in October 2002 and his first actions as president were very exposed to mistrust in early 2003, since he was elected for the defence of ideas that were opposed to the economic mainstream.

In June 2005, the first major scandal related to Lula's government, the so-called "Mensalao", exposed a political corruption scheme through the purchase of votes of members of the Brazilian National Congress, considerably undermining the government's credibility.

The highest point in the series occurred in September 2008, with the collapse of Lehman Brothers and the peak of the American sub prime crisis. This point is remarkable in world history, as well as implying in a series of crises throughout the world also represents a serious flaw in the world's largest economy, which weakened directly the developing economies, such as Brazil. Shortly after the US House rejected the government's proposal to bail out the financial sector on September 29, the Sao Paulo Stock Exchange (the world's third-largest market) fell 10% and had its operations interrupted.

Difficulties with Greek debt began at the end of 2009 but became public only in 2010. The crisis began with rumors about Greece's level of public debt and the risk of Greek government suspension of payments, facts stemming from the global economic crisis and internal financial instabilities. In May 2010, after failed attempts to control debt, the European Union (EU) and the IMF agreed a bailout plan to prevent further progress of the crisis. These facts led to great anxiety of the markets, since the plan showed the severity of the crisis that had been extending for some time.

In the wave of debt collapse, other countries in the euro zone signaled the need for recovery plans to avoid a deeper fiscal crisis. There was a contribution of 100 billion in Ireland at the end of 2010. A lack of confidence emerged in early 2011 due, to the threat of extending the crisis to other countries (notably Portugal and Spain), leading them to take initial austerity measures.

In March 2014 began the largest corruption operation in the history of Brazil: operation "Lava Jato". The investigation was directed at crimes of corruption, fraudulent management, money laundering, among others. The investigations uncovered a network of corruption among administrative members of state oil company Petrobras, entrepreneurs of large Brazilian companies and politicians of largest parties in Brazil, including former presidents, members of the Chamber of Deputies, Federal Senate and governors. The operation gained national and international fame, going through constant attempts of obstruction and revealing a chronic deficiency in the Brazilian institutions. The unfolding of the investigation occurs until the present day.

Even after a serious destabilization of the government base, with various corruption scandals, President Dilma Rousseff was re-elected in October 2014 and began her second government in January 2015. Shortly thereafter, with the worsening of economic indicators and the deepening of political crisis, with protests all over Brazil (in the months of March, April, August and December 2015), the Impeachment process was officially started in January 2016.

Again, the Brazilian economy was severely affected by a wave of insecurity, mainly regarding the direction of the economic policy. In August 2016, the impeachment process was officially approved and President Dilma Rousseff was removed from office. In her place, Vice-President Michel Temer assumed the presidency amid the great controversy and rejection.

In the final part of the estimated ambiguity, we observe a peak in November 2016, coinciding directly with Donald Trump's election in the United States. This victory meant a possible decrease in the intensity of free trade with developing countries, as well as a systemic insecurity about the possibility of clashes with nations possessing nuclear weapons (such as North Korea).

Finally, we observe in May 2017 a relevant movement regarding the increase in ambiguity, which is possibly explained by the last delations of the Lava-Jato operation, which exposed a mechanism of corruption in the country, involving the last governments.

1.4.3 The Economic Robustness of the Ambiguity Measure

We evaluate the economic robustness of the ambiguity time series by checking its relation with measures of uncertainty and risk[8]. We conduct three exercises: i) An OLS regression where the uncertainty (IIE-Br/FGV) is regressed against a measure of risk (Ibovespa Volatility/IPEADATA) and the ambiguity proxy. The results reveal significance, at a level

[8] It is important to note that the robustness tests performed by Izhakian and Yermack (2016) to verify the independence relation of ambiguity and risk, involve of each asset with their respective level of uncertainty. Thus, such direct application becomes impracticable in this study, since we are working with aggregated data (by portfolio and nationally) and our frequency necessarily needs to be reduced to monthly data.

of 5%, of both variables. ii) A Granger-Causality Test indicates that, at a 5% confidence level, ambiguity Granger-causes uncertainty, but the opposite is not verified. In addition risk Granger-causes uncertainty, but the opposite is not valid. Finally, as indicated by Izhakian and Yermack (2016), ambiguity Granger-causes risk but the opposite is not valid. iii) A VAR (1) between ambiguity, risk and uncertainty: starting from the causal logic, we follow Izhakian and Yermack (2016) and define that the ambiguity can affect risk and uncertainty contemporaneously, but it is not affected by either, the risk affects uncertainty but is not affected by the same. As such, uncertainty is the most endogenous variables, responding contemporaneously to both. Our VAR shows that ambiguity and risk shocks positively (and significantly) affect the uncertainty index, but risk and uncertainty shocks do not affect ambiguity. As a robustness check, we change orders and the results are unchanged.

We now proceed to analyze the effects of ambiguity shocks in macroeconomic variables. Our objective in the next section is to understand if the ambiguity proxy has significant effects on economic activity.

1.4.4 The Impacts on Brazilian Cycles

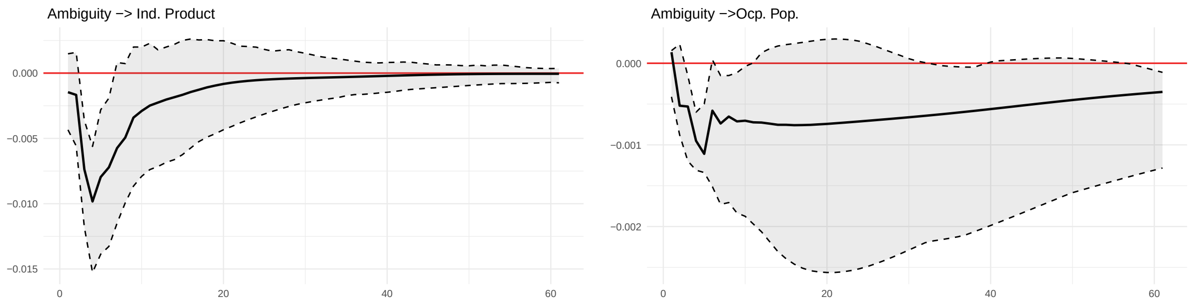
To understand how ambiguity can affect economics, we start with a simple VAR model with 5 variables introducing uncertainty through the separation of ambiguity and a measure of risk. We use the following variables in the respective ordering: ambiguity proxy, Ibovespa volatility , selic (policy interest rate), log(occupied population) and log(industrial production). All variables enter in log, except ambiguity and the interest rate. After this first simple model, we follow for structural analysis in an SVAR and submitted the model to several tests of robustness.

The causal ordering logic in the simple VAR follows what is discussed by Baker, Bloom and Davis (2016). However, it is worth noting that our study has a significant difference in the model of these authors. Here we use uncertainty through two variables: ambiguity and risk in the financial market, that is, we do not place ambiguity, risk and an uncertainty proxy at the same time, since according to Izhakian and Yermack (2016) and Backus, Ferriere and Zin (2015), in the theoretical formulation the latter is a higher state formed by the first two. In other words, simultaneous inclusion may distort the direct effect and significance of ambiguity on the real variables.

The standard unit root tests (ADF, DF-GLS, PP, KPSS) indicate that, except for ambiguity, the other variables are $I(1)$ but cointegrate. Thus, we follow what is presented by Sims (1986) and estimate the models with level variables, since the parameters are consistently estimated in the presence of cointegration [9]. In addition, the number of lags of the VAR model was determined based on the AIC, HQ, SC and FPE selection criteria.

The lags selection criteria indicate 1 or 4 lags, but only in the last case autocorrelation is absent from the residuals, which is the reason we present estimations for a VAR(4). We show the impulse response functions [10] in figure 1.4. Black lines represent the impact on each month, the horizontal red line is relative to the x-axis (or when y = 0) and the shaded areas delimited by dotted lines represent the 95% confidence interval [11].

Figure 1.4: Ambiguity Shock - VAR - Ind. Production and Employed Pop.



Note: Ambiguity Shock, baseline model with Industrial Production.

The IRFs show that a positive shock in ambiguity affects adversely the industrial production and the employment, which is in agreement with what is exposed by Backus, Ferriere and Zin (2015). Estimates indicate that an positive ambiguity shock (one standard deviation) shrinks industrial output by about 0.95% in the fifth month. The impact of ambiguity is slightly smaller than the uncertainty shock reported by Costa Filho (2014) and Barboza and Zilberman (2018). This is expected, since ambiguity is part of uncertainty. For the employed population, the retraction reaches 0.1% in the fifth month. Generally,

[9]Note that the error correction model may be poorly specified when the form of cointegration is not known. Besides that, the estimation with the variables in the first difference, when we have cointegration, implies loss of long-term relationship information. For more details see Hamilton (1994).

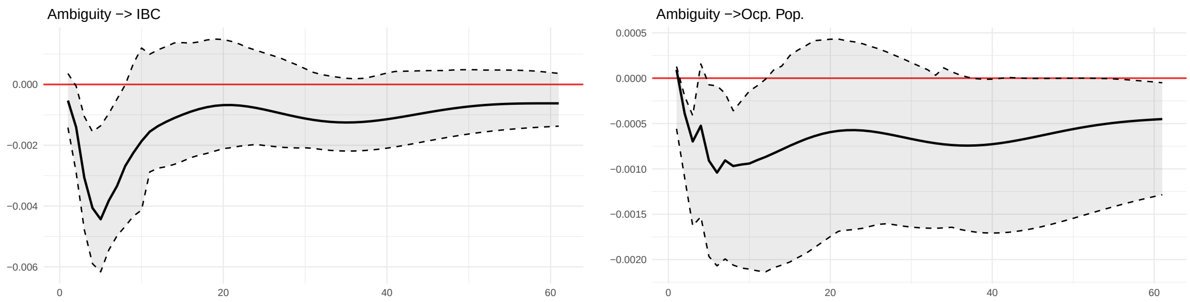
[10]For the stability and robustness tests of the model, we highlight that all roots are within the unit circle, the Portmanteau test accept the null hypothesis of absence of autocorrelation and the multivariate ARCH-LM test accepts the null hypothesis of homoscedasticity, both with a long structure of lags. As we are working with monthly data, we execute the Portmanteau and ARCH-LM tests from 12 to 16 lags and 8 to 12 respectively, to cover a large group and do not ignore the higher order lags. The results are strong valid for all possibilities.

[11] The impulse response confidence intervals are obtained after 10.000 replications and follows Efron (1987) and Hall (1988).

as the RBC literature indicates, we found that the employment response is usually lower than the output response.

We estimate another model using IBC-Br instead of the Industrial Production. Selection criteria and autocorrelation tests also indicated a VAR(4). The IRFs of this new model are presented in Figure 1.5.

Figure 1.5: Ambiguity Shock - VAR - IBC-br and Employed Pop.



Note: Ambiguity Shock, baseline model with IBC-Br.

The responses are very similar to the model with Industrial Production, but the impact on IBC-Br is of smaller magnitude, which makes sense as this index is formed by all sectors of the economy, not only the industry. The impact impact on the fifth month reaches 0.45%.

For robustness, we also estimate the impulse response functions using a an identification strategy that is not recursive. Our identification strategy is summarized in the following matrix:

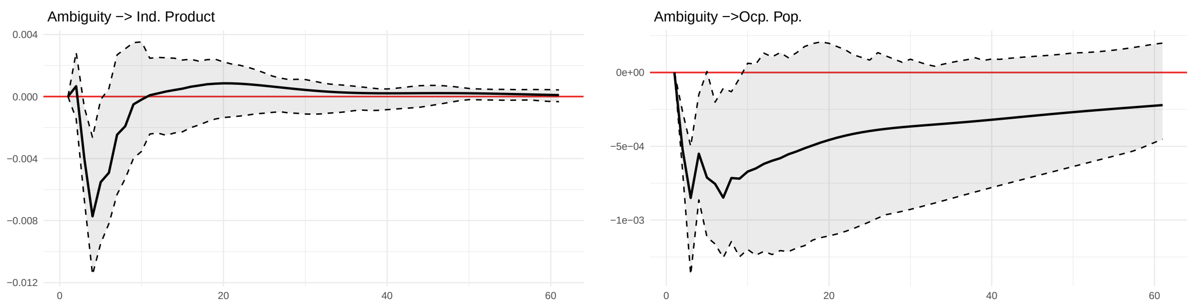
$$A = \begin{array}{c} \\ AMB \\ IBVSP \\ SELIC \\ EMP \\ INDP \end{array} \begin{array}{c} \begin{array}{ccccc} AMB & IBVSP & SELIC & EMP & INDP \end{array} \\ \begin{bmatrix} a_{11} & 0 & a_{13} & a_{14} & a_{15} \\ 0 & a_{22} & a_{23} & a_{24} & a_{25} \\ 0 & a_{32} & a_{33} & 0 & 0 \\ 0 & 0 & 0 & a_{44} & 0 \\ 0 & 0 & 0 & a_{54} & a_{55} \end{bmatrix} \end{array}$$

Each line in matrix A correponds to one specific equation. As an example, when we determine that the element $a_{12} = 0$, this means that in the structural model, Ibovespa Volatility does not affect the level of ambiguity contemporaneously.The logic of the matrix of contemporary effects is the following: we assume initially what is exposed by Izhakian and Yermack (2016), risk does not affect ambiguity and vice versa. The macroeconomic oscillations can affect the agent's perception of future states. In addition, the monetary authority observes and reacts to fluctuations in risk variables, but it can't observe (within the same month) the ambiguity level[12] and the variables of output and employment, which impedes their immediate action [13].Moreover, given the high level of bureaucracy in the Brazilian labor market and frictions in the hiring/firing process, we assume that the employed population does not respond contemporaneously to changes in production. But on the other hand, the production responds simultaneously to a hiring shock.

As explained in the methodology, the basic model remains the same and all stability and test properties regarding autocorrelation and heteroscedasticity remain. The only difference is that we retrieve the contemporary coefficients, which can affect the format of the IRF presented. We present the IRF for industrial production and employment, the other impulse response functions can be found in Appendix.

In the structural model, we can see that the ambiguity remains significant, with a slightly weaker effect, 0.78%, in the fifth month. For employment, we observe a similar effect, but the retraction is now 0.05%. This reinforces the adherence of the hypothesis of negative effects on the real economy.

Figure 1.6: Ambiguity Shock - SVAR - Industrial Production and Employed Population



Note: Ambiguity Shock, baseline structural model with Industrial Production.

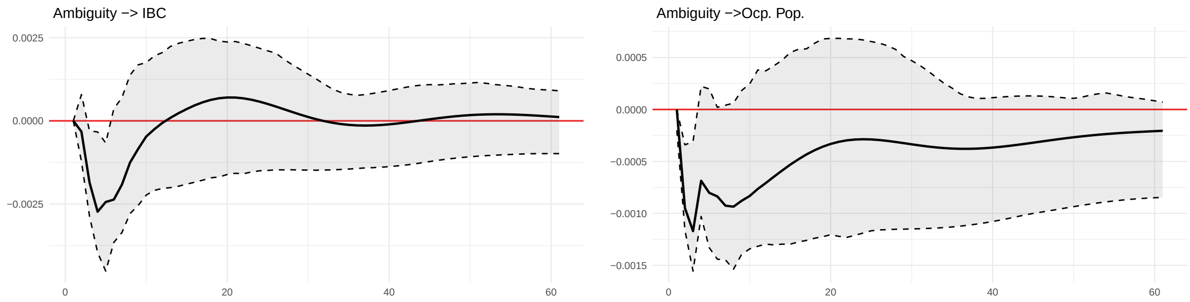
Following, replacing the industrial production by IBC-Br, as expected the IBC-Br presents a smaller retraction than the industrial production, approximately 0.43%. As for employment, we observe a retraction peak of 0.10% in the fifth month.

Our analyses indicate that a positive shock to ambiguity reduces economic activity and employment. We now conduct a robustness check to verify if our conclusions remain after changing some aspects of the previous estimations.

[12]We adopt this hypothesis because even if there is some notion about the level of uncertainty in the economy, there are no indicators for ambiguity in a disaggregated form that can be observed in short periods of time.

[13]See Leeper *et al.* (1996) and Barboza and Zilberman (2018)

Figure 1.7: Ambiguity Shock - SVAR - IBC-Br and Employed Population



Note: Ambiguity Shock, baseline structural model with IBC-Br.

1.4.5 Robustness Tests

The first robustness exercise verifies the impact of computing the ambiguity proxy by different methods. In sequence, we tested the robustness of the results in the VAR/SVAR models. We performed several modifications in the proposed model and analyzed how the results change. All tests are performed for both the Industrial Production and IBC-Br.

1.4.5.1 Different Proxies

In this subsection, we investigate variants in the treatment of the densities used in the estimation of ambiguity. We performed six different procedures and, for comparability, we normalize all series[14] to test the robustness of the results:

(i) *We change the reference point in the calculation of the probabilities for each density function: instead of using the interbank interest rate (CDI), we adopt zero as the reference point;*

(ii) *We use the Uniform distribution, where the percentages are relative to the frequency of portfolios that show a return lower than the CDI in each day;*

(iii) *We analyzed only the left tail of the distribution of returns (values below CDI) for the calculation of the probabilities;*

[14] The series can be found in Appendix.

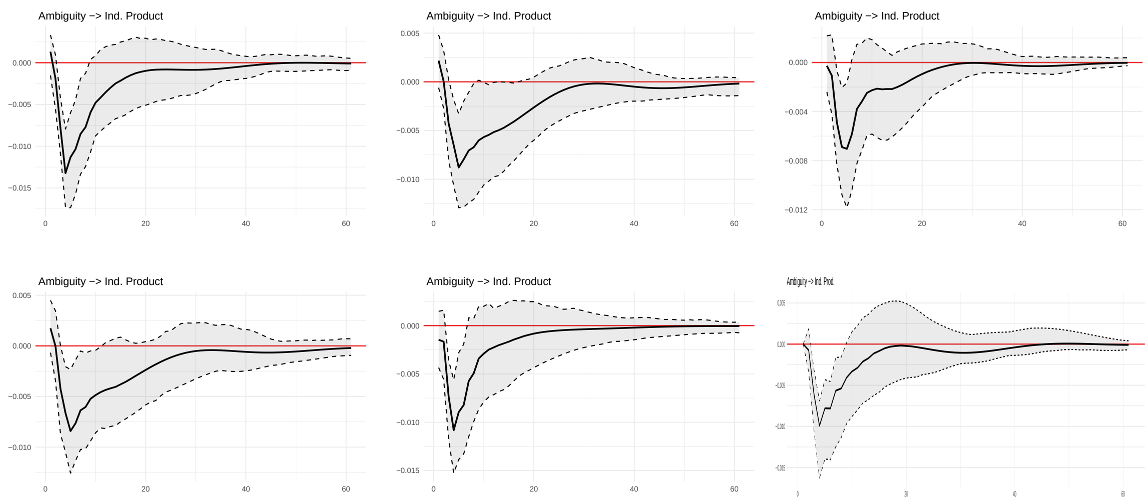
(iv) *We analyze only the left tail of the distribution of returns (values below zero) for the calculation of the probabilities;*

(v) *We change the normal distribution assumption for the daily stock returns by t-student distribution;*

(vi) *We simulated the daily density using the Fama French model of five factors as the generating process, estimated with quantile regressions.*

Again, we performed the tests on the VAR / SVAR models for both Industrial Production and IBC-Br. As can be seen in the figure below, for all the changes presented, using a simple VAR model, the effect of an ambiguity shock on industrial production remains as expected, a retraction peak between 0.70% and 1.10%.

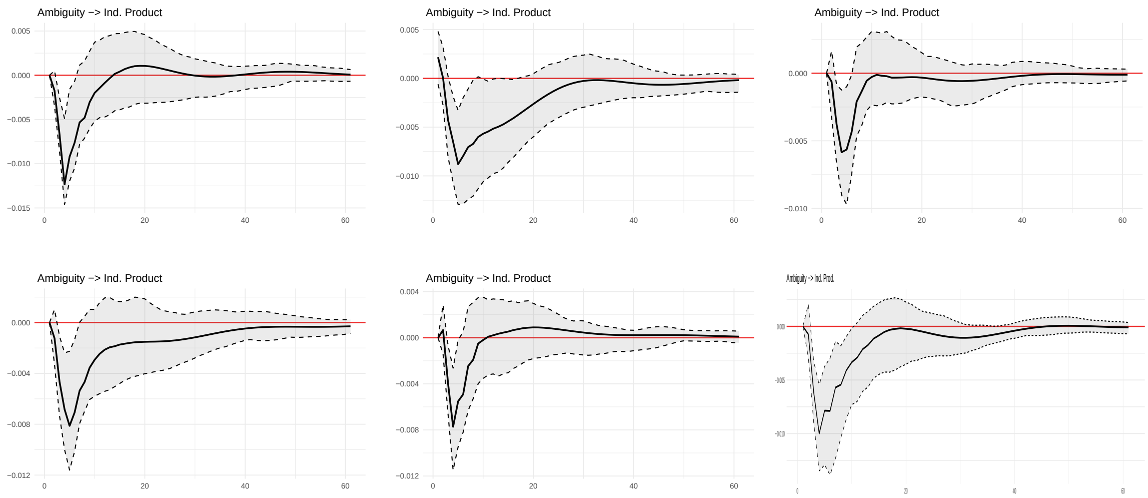
Figure 1.8: Proxies - Industrial Production VAR



Note: From left to right, the first three graphs represent the robustness tests from i to iii and the last three from iv to vi.

In the structural model, for industrial production, we observed that the performed changes do not significantly affect the results found. It is estimated that a ambiguity shock will reduce industrial output by up to 0.60% and 1.10%.

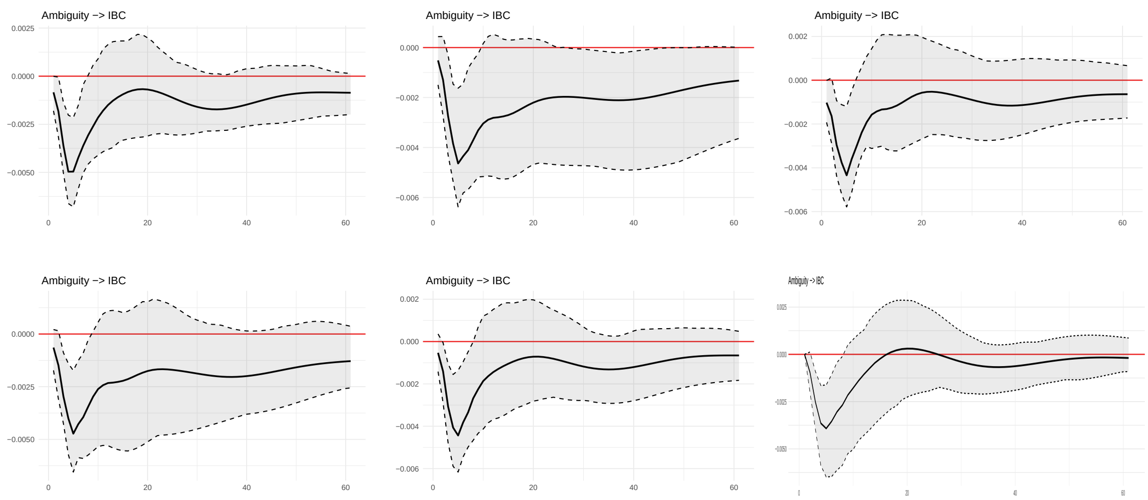
Figure 1.9: Proxies - Industrial Production SVAR



Note: From left to right, the first three graphs represent the robustness tests from i to iii and the last three from iv to vi.

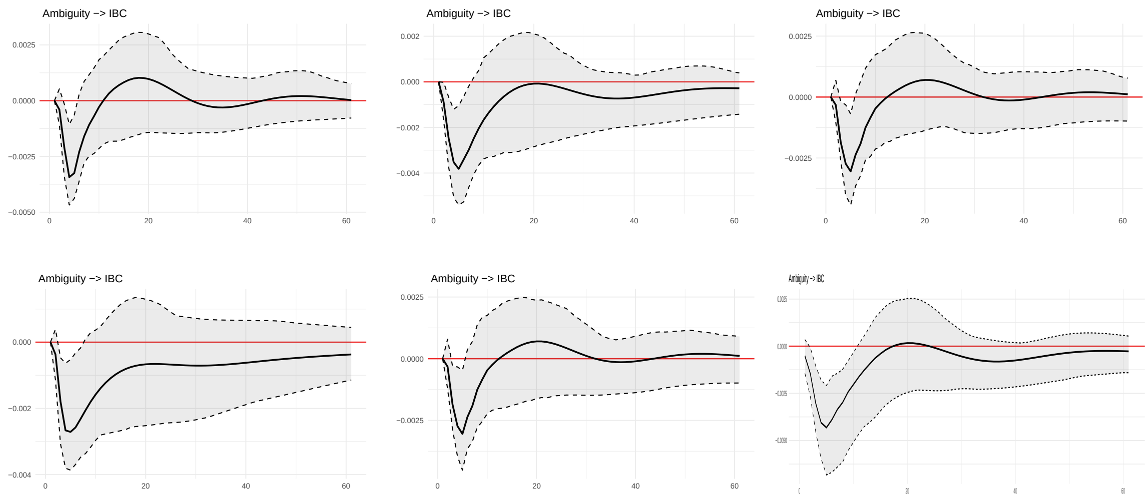
These results suggest that ambiguity can significantly affect economic cycles when we consider industrial production as a proxy. Changing the proxy for economic activity, we observe the following results:

Figure 1.10: Proxies - IBC-Br VAR



Note: From left to right, the first three graphs represent the robustness tests from i to iii and the last three from iv to vi.

Figure 1.11: Proxies - IBC-Br SVAR



Note: From left to right, the first three graphs represent the robustness tests from i to iii and the last three from iv to vi.

Finally, for the proxy that covers a larger number of sectors of the Brazilian economy, the effects are significant and the simple vector model indicates a decrease between 0.4% and 0.5%.

The same is verified for the structural model with IBC-Br. The effects of an ambiguity shock are negative, leading to a retraction between 0.3% and 0.4% of production. The estimated models suggest that the relationship between ambiguity and economic activity is small but significant.

1.4.5.2 VAR/SVAR

We will focus specifically on the effect of ambiguity on production (Industrial Production and IBC-Br), but all other IRFs can be found in Appendix. We analyze the following changes:

(a) Variable Exclusion: *Employment*;

(b) Variable Exclusion: *Ibovespa*;

(c) Variable Inclusion: *Effective Real Exchange Rate*;

(d) Variable Inclusion: *IPCA*;

(e) Variable Inclusion: *Emerging Markets Bond Index*;

(f) Lags Change: *Increase* of One Lag;

(g) Lags Change: *Decrease* of One Lags;

(h) Change in *Ordering*[15];

(i) Change in *Ordering*[16];

(j) Change in *Ordering*[17];

(k) Change in *Ordering*[18];

(l) Trend: Series Trend Removal (*HP Filter*);

We can observe that even after the twelve robustness tests, in the simple VAR model, the industrial production response to an ambiguity shock remains, approximately a peak of 0.90 %, with significant effects between the first and ninth months. The same is valid for the SVAR model, but with a slightly higher oscillation in the industrial production, always remaining between 0.60% and 1.10%.

Again, as expected, the IBC-Br proxy response seems to be robust to all changes suffered by the models, holding between 0.25% and 0.50%, in both VAR and SVAR models. Thus, it seems that the ambiguity proxy fulfills the expected role, according to the theory.

[15] Product, Occupied Population, Selic, Ambiguity and Ibovespa Volatility. Matrix of *Contemporary Effects*: The Central Bank does not react to financial variables, only real ones.

[16] Product, Occupied Population, Selic, Ambiguity and Ibovespa Volatility. Matrix of *Contemporary Effects*: The Central Bank reacts to all variables, Ibovespa Volatility is affected by all the variables, the ambiguity does not react to any variable and the production responds only to shocks in the occupied population and ambiguity

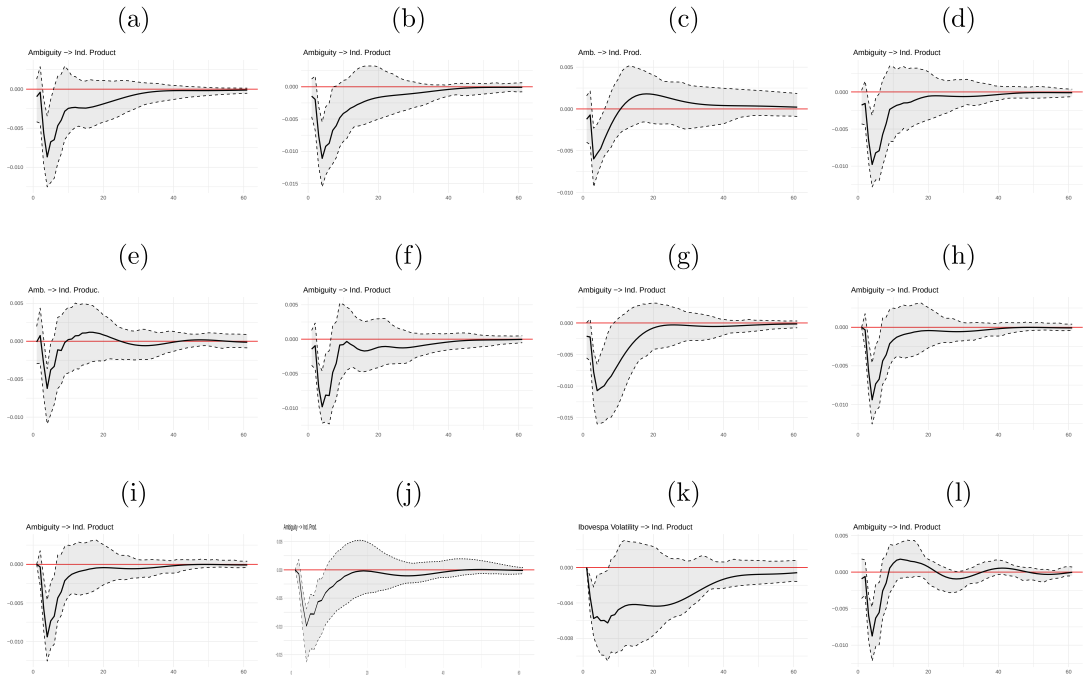
[17] Selic, Product, Occupied Population, Ambiguity and Ibovespa Volatility. Matrix of *Contemporary Effects*: The Central Bank does not react. In addition, the Ibovespa Volatility is affected by all the variables of the model, the ambiguity does not react to any variable and the production responds only to shocks in the occupied population and ambiguity

[18] Product, Occupied Population, Selic, Ibovespa Volatility and Ambiguity. Matrix of *Contemporary Effects*: The Central Bank does not react to financial variables, only real ones.

Retracing the economic activity, mainly in the industrial sector where the impact presents superior magnitude.

It is important to highlight that all 12 tests performed, for both the VAR model and the SVAR model, showed stability (or roots of the inverse polynomial outside the unit circle), were robust to autocorrelation and heteroscedasticity and followed the lags suggested by the usual selection criteria.

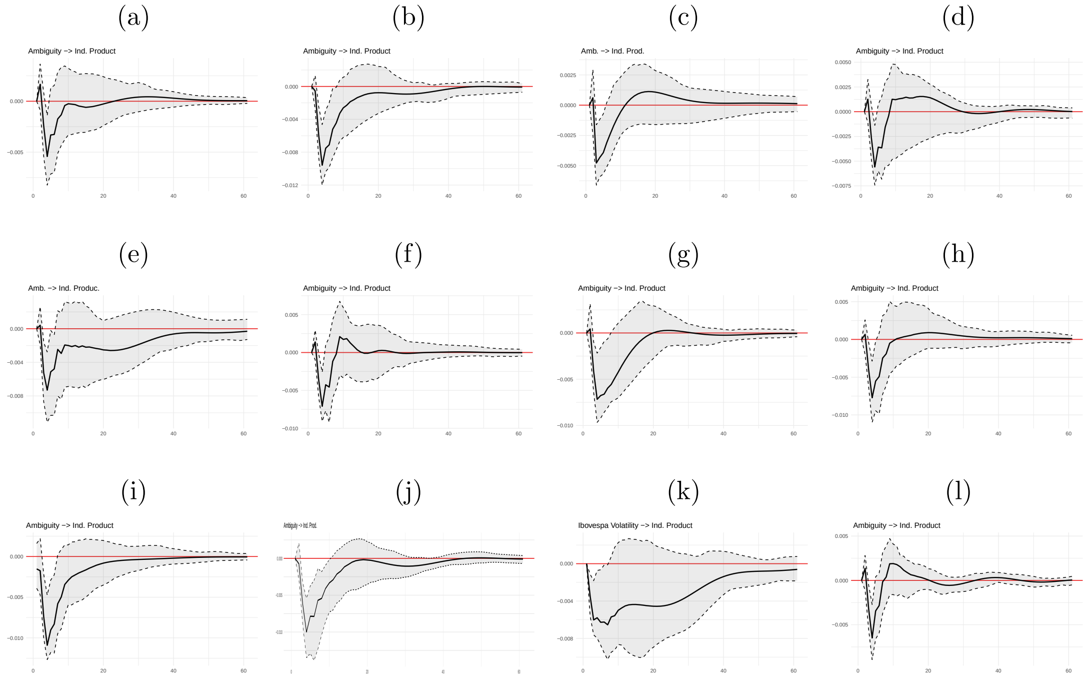
Figure 1.12: Robustness - Industrial Production VAR



Note: Robustness tests, VAR model with industrial production..

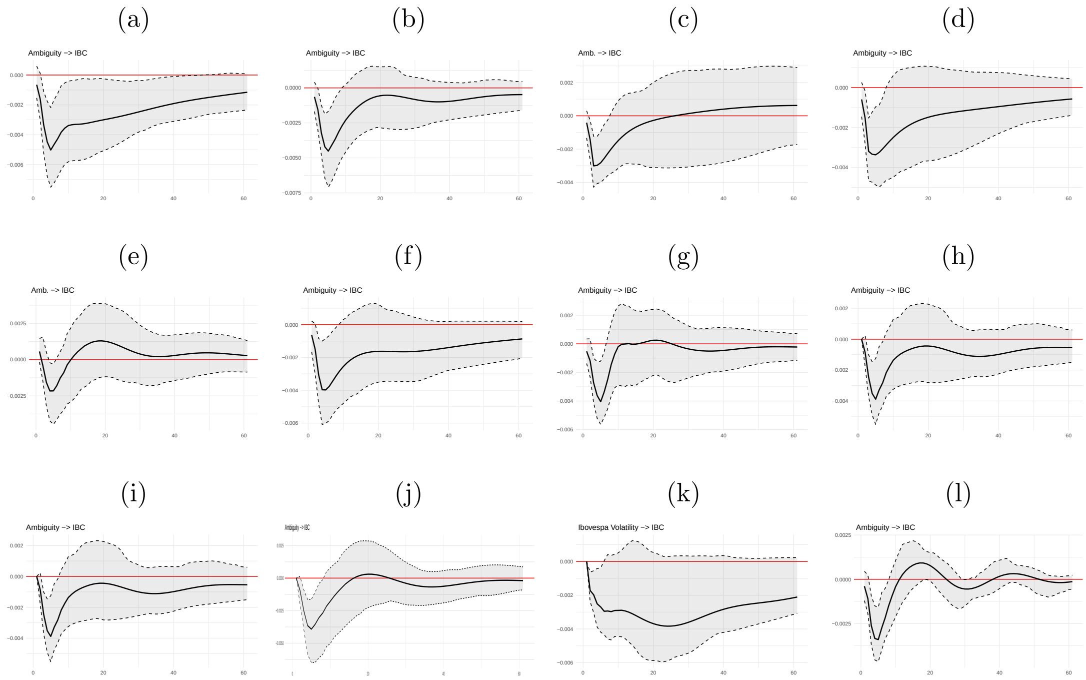
To conclude the robustness analysis, as discussed in the previous section, we have tested Embi as alternative proxy to filter risk in economy. Here we point out that all the models tested for robustness (from a to l) were also simulated with this variable (Embi) and the results are the same as when we maintain Ibovespa. Furthermore, we run all tests with the logarithm of ambiguity and the results also do not change. Thus, after all these simulations, we verify that sudden increases in the ambiguity causes the economic activity to drop.

Figure 1.13: Robustness - Industrial Production SVAR



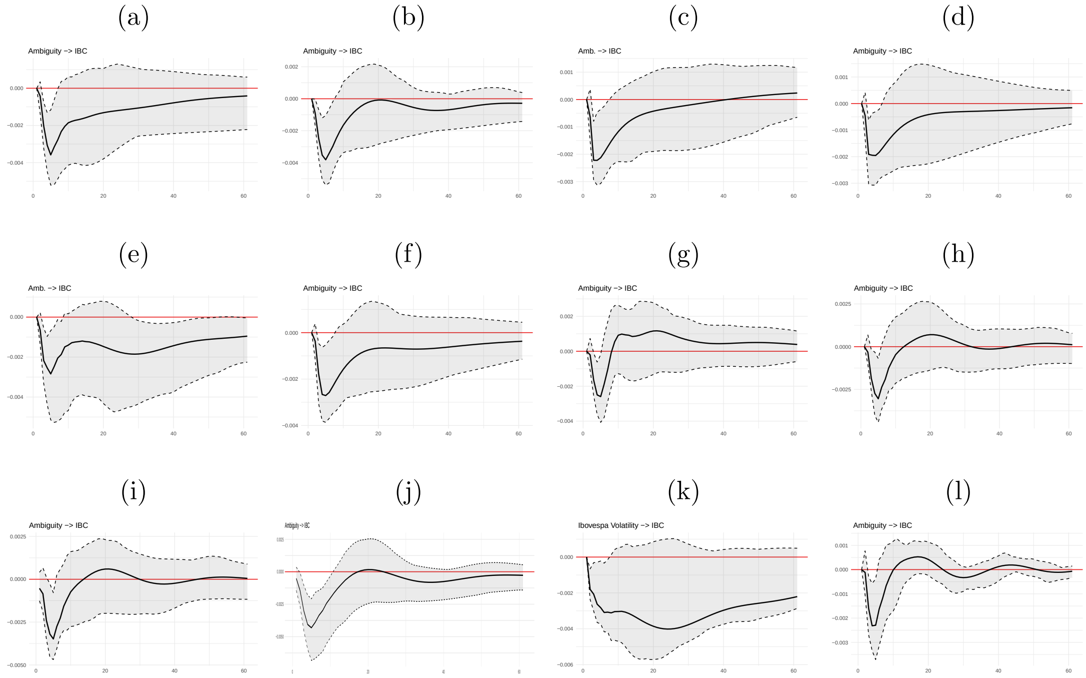
Note: Robustness tests, SVAR model with industrial production..

Figure 1.14: Robustness - IBC-Br VAR



Note: Robustness tests, VAR model with IBC-Br.

Figure 1.15: Robustness - IBC-Br SVAR



Note: Robustness tests, VAR model with IBC-Br.

1.5 Conclusions

In this essay we estimated a proxy for ambiguity and measured its impact on the Brazilian economic activity. Our results can be divided into the same two groups.

From jan/2000 to jun/2017 we construct daily portfolio densities and define standard bins to be applied to all densities. We use Interbank Deposit Certificate (CDI) returns as a reference point and select the area from -10% to $+10\%$ around the reference point and split the distribution in 0.5% intervals. From these bins we calculate the probabilities through the area below the curve (definite integral) in the respective interval that delimits the bin. Then, we measure ambiguity as the total variation of probabilities in each bin within a month, weighted by the expected probability.

The series has an average of 0.012 and standard deviation 0.013. It has a positive asymmetry of 0.641, indicating that the values are concentrated to the right of the distribution. Finally, the kurtosis of 4.412 suggests a fat tail pattern. We evaluate the economic robustness of the ambiguity time series by checking its relation with measures of uncertainty and risk. As expected, and suggested by Izhakian (2017) ,ambiguity affect uncertainty, but the opposite is not verified.

Finally, we proceed to analyze the effects of ambiguity shocks in macroeconomic variables. The results are revealing and show that in general we can expect a decrease of approximately 0.60% to 1.10% for industrial production and 0.25% and 0.50% for IBC-Br. Moreover, we tested the robustness of the results in the VAR/SVAR models and verify that sudden increases in the ambiguity causes the economic activity to drop. Our results are in agreement with the Brazilian empirical literature, since the impact of ambiguity is slightly smaller than the uncertainty shock reported by Costa Filho (2014) and Barboza and Zilberman (2018).

Chapter 2

The Role of Expectations on Brazilian Inflation

2.1 Introduction

The importance of expectations in the process of price formation has been discussed since Friedman (1968) and Phelps (1967). However, this debate was incorporated into the Phillips curve in the new keynesian version, which determines current inflation as a combination of expectations, lagged inflation and output gap. Mankiw, Reis and Wolfers (2003) argue that disagreement about inflation expectations is one of the most important variables of contemporary macroeconomics, because inflation expectations may capture future macroeconomic conditions, according to market projections.

As an example, the inflation targeting regime seeks to keep inflation low, but the effectiveness of the monetary authority depends directly on its power to anchor expectations. Taylor (2012) indicates that the discretion of the monetary authority can increase the persistence of inflation, through expectations. Coibion, Gorodnichenko, Kumar and Pedemonte (2018) argument that higher inflation expectations lead firms to immediately raise prices and workers to bargain for bigger nominal wages, as an attempt to anticipate future increases. In other words, in instability phases, attitudes that weaken monetary credibility can negatively affect agent expectations and induce higher current price volatility.

However, a considerable part of macroeconomic models understand the effect of expectations through an average estimated value. Ignoring that monetary policies, in different periods of the price cycles, can affect not constantly the trajectory of this variable. Consequently, when verified, the asymmetry should always be accounted for, since it allows macroeconomic models and forecasting tools, for policy-makers, to present more adequate performance. Intuitively, this means that policy proposals based on symmetrical estimations can not be generalized in extreme periods.

Some international studies, such as Buchmann (2009), Balaban and Vintu (2010),Nell (2006), Huh and Lee (2002) and Eliasson (2001), reinforce the presence of asymmetry in inflation dynamics through the estimation of the New Keynesian Phillips curve. Moreover, recently some studies have focused on the use of quantile regressions to investigate the slope variation in different regions of the response variable distribution, such as Euro Area by Chorteas and Panagiotidis (2012) and Turkey by Boz (2013).

Dealing with domestic price dynamics, the Brazilian economy experienced periods of hyperinflation in recent history, often reaching three digits in the 1980s. But since the 1990s, after the implementation of *Plano Real* in 1994, the price index returned to stability. Although the average inflation rate was 6.45% from 1996 to 2014, the inflation response to various shocks, such as expectations, exchange rate and output gap, does not necessarily occur symmetrically. The Extended Consumer Price Index (IPCA), for example, reached double digits in 2015, an unusual event since 2002. We believe that the Brazilian supply curve estimates must consider the evidence of asymmetry found by Correa and Minella (2010), mainly for the forward-looking component.

Therefore, besides the use of quantile regressions to analyse Brazilian price dynamics, we advance in the investigation of asymmetry in expectations of the aggregate supply curve, verifying the existence of differences in the conditional distributions of inflation. Specifically, we seek to understand whether low/high expectations are related to lower/higher dispersed current inflation in Brazil, similar to the idea presented by Coibion, Gorodnichenko, Kumar and Pedemonte (2018).

The results provide evidence that the forward-looking and backward-looking components appear to be significant in all estimates (2SLS,GMM and QR). Furthermore, the highest effect of the forward-looking component, as indicated by Areosa and Medeiros (2007), is valid only at the higher quantiles. In periods of low inflation, our estimates are closer to the Mazali and Divino (2010) conclusions, which indicate a higher magnitude of the lagged component compared to expectations. Our asymmetry pattern is similar to what was found by Chorteas and Panagiotidis (2012) for Eurozone, dominance of expectations only at the higher quantiles of the conditional distribution of inflation.

In the estimation of the density functions, we reinforce the evidence of asymmetry through changes in the dispersion of the conditional distributions (standard deviation and range), indicating that periods with low inflation expectations result in lower dispersed conditional distributions of inflation rate.

2.2 References About Price Dynamics and Expectations

2.2.1 Theoretical

The Phillips curve represents a famous macroeconomic supply curve based on the correlation between prices and real aggregates. The theoretical construction was originally proposed by Alban William Phillips in 1958, which suggested that low levels of unemployment led to higher wages. But the notion of the Phillips curve as a policy tool was first exposed by Samuelson and Solow (1960).

According to the original view, the Phillips Curve was interpreted as a stable long-term trade-off that provided a set of possibilities between inflation and unemployment for optimal policy choice. However, in the first part of the 1970s, inflation and unemployment increased together. This phenomenon, named "stagflation", weakened the view of an inverse and stable relation between variables. Authors of the New Classical school, such as Lucas (1972) and Sargent and Wallace (1973), explored more the phenomenon. Lucas (1972) argues that if economic policy is changed, the formation of expectations changes, and therefore the effectiveness on economic outcomes is different.

In other words, they argued that demand-driven policies (fiscal and monetary) could not have an impact on output and employment, both in the short and long terms, due to the validity of rational expectations and market clearing assumptions[1]. Thus, for these academics, the inflation's dynamic followed a mix between rational expectations and flexible prices.

This proposition of monetary policy neutrality, in the adjustment process of the real variables, came into conflict with the data analyzed in subsequent periods. But it was only in the 1990s that the New Keynesian models, based on rational expectations and price rigidity, revived the discussion about the Phillips Curve, showing new theoretical arguments with empirical evidence.

The attention given to New Keynesian Phillips Curve (NKPC) emerges due to the application for policy-makers. According to Gali (2008), inflation represents a level of

[1]According to this school, an exception would be possible only in the very short term, when monetary policy is not anticipated.

economic inefficiency that is measured in terms of output gap component, expectations and nominal rigidity. If monetary policy seeks to stabilize prices, then it contributes significantly to increasing the efficiency of economic activity.

To reaffirm this effect of monetary variables, the formulation of the New Keynesian Phillips Curve (NKPC) was based mainly on three contributions: Taylor (1980), Rotemberg (1982) and Calvo (1983). The NKPC has been widely used in dynamic inflation models for monetary policy analysis. In short, Christiano and Evans (2005), Blanchard and Galí (2007) and Gali (2011) argue that the construction of NKPC is a combination of real business cycles theory with central aspects of Keynesian theory. This specification is usually obtained by mathematical derivations that take into account the interaction between agents in a micro-based economic system, with firms and consumers optimizing their choices.

The mathematical derivations focus on the effects of price/wage rigidity on the cyclical fluctuations of output and unemployment, which the previous authors understand as fundamental components of Keynesian theory. As an example, assuming a model with imperfect competition and information asymmetry, the effects of rigidity pass through the channel of adjustment between aggregate supply and demand. Furthermore, if agents form their expectations in a "rational way" [2], rigidity affects the dynamics of the economy on both real and monetary sides.

The final specification is obtained by a Dynamic Stochastic General Equilibrium (DSGE) model [3], which considers nominal rigidity following Calvo (1983). Basically, according to this approach, current inflation becomes a function of inflation expectations and real marginal costs.

But this representation was severely criticized for omitting the inflationary inertia verified in the data. This persistence problem was solved by constructing a model that included the term backward-looking and led to better empirical performance. Gali and Gertler (1999) constructed this variant from Calvo's price structure and complement the analysis by assuming that only a part of the optimizing firms uses all the available information to determine the price, the remaining choose following a simple rule based on the past behavior of the aggregate prices.

Furthermore, Blanchard and Galí (2007) demonstrate that we can rewrite the NKPC in a third hybrid way. Starting from a model based on the second best, they introduce

[2] For rational way, we mean that the expectations of economic agents about variables are correctly formed when there is a coincidence between their particular expectations and the mathematical conditional expectation of the stochastic process, as emphasized by Muth (1961).

[3] See Gali (2008) for more details of derivations.

exchange rate shocks and economic cycles in the Phillips Curve. The derivation follows the same steps as the standard New-Keynesian model, but now the stabilization of the gap is no longer desirable, since the gap between the first and second best output levels is not constant, reacting to the shocks.

However, before reviewing the papers that try to estimate the Phillips Curve in the Brazilian case, it is important to highlight a current problem reported in the literature: endogeneity. Nevertheless, if we manipulate the equations, it is possible that inflation expectations also affect current inflation. However, there are feasible solutions that allow more consistent estimates of this dynamic, which will be discussed in the next topic.

2.2.2 Empirical

Empirical results regarding the Phillips curve diverge considerably. Gali and Gertler (1999) estimate NKPC for the US economy and find that real marginal cost and inflation expectations are important in determining current inflation. In this same approach, Gali,Gertler and Lopez-Salido (2001) observe similar results for the Euro area. The authors note that even the simplest version of the NKPC, without the backward-looking component, represents a good approximation of the inflation dynamics in the United States and Europe.

Other studies such as Rudd and Whelan (2005) Rudd and Whelan (2007) and Stock and Watson (2007) provide a counterpoint to previous results. For these researchers, estimates of the New Keynesian Phillips Curve that consider the forward-looking term, but omit the backward component, verified in the data, can not be a good approximation of reality.

However, even the works exclusively focused on the analysis of the hybrid specification diverges about the validity and significance of the hypotheses: Roberts (2001) and Estrella and Fuhrer (2002) present evidences that the backward-looking component appears to have a large significant effect on US inflation, but the results of Roeger and Herz (2012) show the prevalence of the forward-looking models after testing traditional and New Keynesian Phillips curve specifications.

In the Brazilian case, some papers try to estimate the parameters of the Phillips curve. Minella and Muinhos (2003) develop a research for the period from 1995 to 2002 and provide important results about Brazilian price dynamics and monetary policy. The authors focus on the Taylor Rule and Phillips Curve estimates. Using IPCA for price variation and the unemployment measured by IBGE, they find that the Hybrid Phillips Curve without expectations has parameters of 0.56 to 0.62 for lagged inflation and -0.09

to -0.08 for unemployment, these results vary according to the dummies specifications and lag inclusions.

Mendonca and Santos (2006) investigate the effects of monetary credibility on the Phillips curve in the period after the implementation of the target regime. The variables used are the open unemployment rate and the inflation expectations, published monthly between 2000 and 2005 by IBGE and Brazilian Central Bank, respectively. Estimates indicate that the use of credibility improves the predictive power of regression. The inflation expectations present a parameter between 0.43 and 0.96 and the unemployment gap between -0.09 and -0.16[4].

Areosa and Medeiros (2007) test a variation of the NKPC in a structural model for open and closed economy. The variables used as proxies for the gap/marginal cost are: wage mass and industrial output. Furthermore, IPCA is adopted as a measure of prices. The Generalized Method of Moments (GMM) estimates indicate that lagged inflation is significant and has a coefficient close to 0.45 in the closed economy, but in open economy the range is 0.1 to 0.37. Expectations are dominant in both models, with a coefficient of 0.53 in the closed model and between 0.63 to 0.81 in the open one. The impact of the real side, measured by marginal costs, is not significant in the first case and negligible in the second, for both proxies. Therefore, the authors conclude that the introduction of the exchange rate seems to be important in the Brazilian case, positively affecting the forward-looking component estimates, from 1995 to 2003.

In the other hand, Mazali and Divino (2010) emphasize the importance of the backward-looking component in the Brazilian data adjustment. They advance estimating the Phillips Curve, from 1995 to 2008, using a similar version presented by Blanchard and Galí (2007). After application of the GMM method, the parameters found were 0.59 for lagged inflation, 0.44 for inflation expectations and about -0.13 for unemployment.

Based on more recent data, Mendonca and Medrano (2012) suggest that the modified version of the NKPCH has difficulties in representing the Brazilian price dynamics. For these researchers, only the effects of inflation expectations and lagged inflation remained robust on inflation dynamics, after GMM estimations. In other words, econometric divergences also occur in the Brazilian case, often through the use of different methods, proxies and instruments.

Currently, there is a growing interest in the possibility of asymmetries in the Phillips curve. Although the traditional theory suggests a linear relationship, authors such as

[4]Again, the results differ according to the specifications

Buchmann (2009) and Balaban and Vintu (2010) argue that the Phillips Curve has never intended to describe a symmetrical relationship. This asymmetry was verified in some countries: United States, Sweden and Australia by Eliasson (2001), Canada by Huh and Lee (2002), South Africa by Nell (2006), Brazil by Correa and Minella (2010), Euro Area by Chorteas and Panagiotidis (2012) and Turkey by Boz (2013).

An approach that has gained some attention in the studies of asymmetry is the quantile regression. Chorteas and Panagiotidis (2012) examine the asymmetry in distribution of Euro Area inflation at various quantiles. They estimate NKPC using two-stage quantile regressions to solve the problem of endogeneity. The results suggest that the inflation response, over the years, is asymmetric at various quantiles. But when inflation is high, the forward-looking component is significant and dominates the lagged component. Boz (2013) performs the same estimation procedure for Turkey, finding relevant differences in inflation response to changes in explanatory variables at various points of the distribution.

As we saw, in Brazil the Generalized Method of Moments (GMM) has been widely used in the estimates of the Phillips Curve components. The main argument, of this application, is usually the robustness for the treatment of the endogeneity bias, which in NKPC is caused by inflation expectations and output gap. However, starting from the strong internal and external oscillations that Brazil experienced in the last decade, according to Aragon and Medeiros (2015), we can expect some asymmetry in the effect of Phillips Curve components on inflation. Then, these mean estimations presenting an incomplete picture of the data distribution and ignore asymmetry.

Some papers find evidence of this asymmetry using the following formulations: i) Estimation of nonlinear forms and functional variants of the Brazilian Phillips Curve, by Correa and Minella (2010), Carvalho (2010) and Arruda and Castelar (2011) and ii) Investigation of structural breaks over the years, by Medeiros and Aragon (2015).

We propose a different approach, that allows us to study the asymmetric behavior of expectations through the Phillips curve. For this, we will use Two Stage Quantile Regressions (TSQR) that provides a larger picture of the data distribution and allow us to solve endogeneity problems from the Hybrid New Keynesian Phillips Curve. In addition, we test variants for input of the real variables, time frequency, lag extensions of pass-through and data frequency, seeking to contribute with the Brazilian literature. Finally, we advance in the investigation of expectations asymmetry by estimating the conditional density functions.

2.3 How to Check the Asymmetry?

The Quantile Regressions (QR) method was introduced by Koenker and Bassett (1978). From this analysis, the researcher can estimate the relationship between a set of explanatory variables x and the τ conditional quantile of the dependent variable y. Unlike the 2SLS and GMM models, that are estimated on the mean of the response variable distribution, this approach is a useful technique because it allows us to study the effect of an explanatory variable at various conditional quantiles of the dependent y_t. Moreover, QR can even model a heteroscedasticity present in the relationship between y and x. It also allows the modeling of unsual density functions, with different shapes, since the procedure does not rely on any parameterized distribution.

Consider a vector of continuous response variables $y = (y_1, y_2, ...y_t)$ and another vector of explanatory $x = (x_{1i}, x_{2i}, ..., x_{ki})$, with subscript i representing the independent variables. A standard linear regression model can be written as $E(y|x) = x^{'}\beta$, such that β is a vector of k parameters. Consequently, a quantile regression model can be understood as $Q_y(\tau|x) = x^{'}\beta(\tau)$, such that $\beta(\tau)$ is a matrix with dimensions of k parameters by τ quantiles, representing the effects of explanatory variables at various points of y.

The construction of the confidence intervals is performed by the moving blocks bootstrap standard errors, which are more commonly used than the standard analytical errors [5]. The moving blocks bootstrap methodology is preferable since it makes no assumption about the distribution of the response variable, being able to generalize the (QR) results and estimate the intervals in any case of residual distribution and provides heteroscedasticity and autocorrelation robust standard errors.

In order to investigate the possible asymmetric effect of the forward looking component in inflation distribution, we estimate the conditional quantile density functions, using the empirical quantile function for the linear model proposed byKoenker and Bassett (1978).

2.3.1 Our Proposal

Our focus is on the empirical approach, we seek to test specifications based on recent econometric literature. Given the evidence discussed in the previous section, we use the hybrid version of the Phillips curve to understand the dynamics of the aggregate supply curve. Specifically, following what is exposed in the works of Bogdanski, Tombini and Werlang

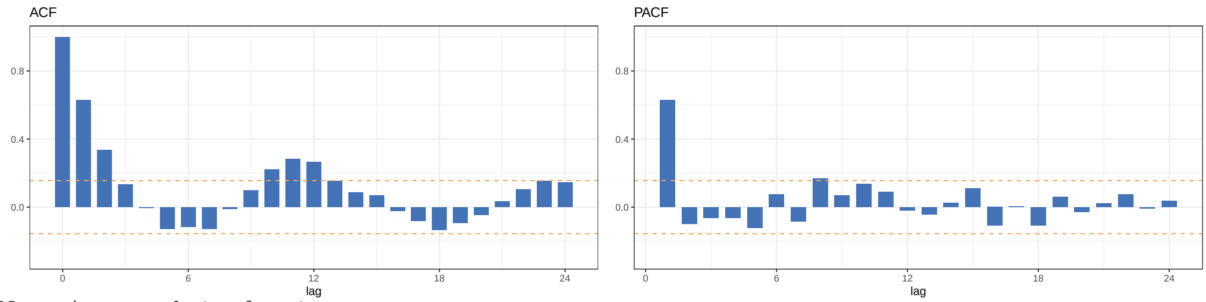
[5]Even when the residual errors are asymptotically distributed according to a normal

(2000), Mendonca and Torres (2015) and Rios-Lopes, Jesus and Rivera-Castro (2018) regarding the importance of Brazilian pass-through and extent of the effect of expectations, we estimate:

$$\pi_t = \Psi_1 \pi_{t-1} + \Psi_2 E_t[\pi_{t+12}] - \Psi_3 x_t + \Psi_4(\Delta v_t) \tag{2.1}$$

To justify the first autorregressive lag term and the extended expectations and the pass-through, we present the autocorrelations and partial autocorrelations functions (ACF and PACF) for Brazilian inflation:

Figure 2.1: ACF and PACF - Inflation



Note: Autocorrelation functions.

As we can see in figure 2.1, the ACF reveals a sinusoidal behaviour typical of the autoregressive process. Additionally, the PACF has significance in the first and eighth lags, indicating that the model has an immediate autoregressive component but horizons over a month may be important in the dynamics of current inflation.

For the estimation process, we need to consider that the Phillips curve present an endogeneity problem. Consequently, the simple Quantile Regression estimation is inconsistent and must be replaced by the Two Stage Quantile Regression (TSQR) method. To deal with heteroskedasticity and autocorrelation we use the *Moving Block Bootstrap* by Fitzenberger (1998).

Moreover, we perform some robustness tests, changing the variables and the periodicity of the data. Then, we focus on the investigation of the asymmetry present in the aggregate supply curve. For this, we estimate the conditional density functions for the response variable (inflation) and we verify if the expectations affect differently the dynamics of this variable.

All the data are analyzed in monthly frequency. The inflation rate (π_t) is measured by the IPCA (Broad National Consumer Price Index) and seasonally adjusted using the

Table 2.1: Variables

Name	**Time**	**Source**	**Sample Size**
Current Inflation	2003:01-2016:02	IBGE	158
Lagged Inflation	2003:01-2016:02	IBGE	158
Inflation Expectations (t+12)	2003:01-2016:02	BACEN	158
Industrial Product	2003:01-2016:02	BACEN	158
IBC-Br	2003:01-2016:02	BACEN	158
Wage Mass	2003:01-2016:02	IBGE	158
Unemployment Rate	2003:01-2016:02	IBGE	158
Nominal Exchange Rate	2003:01-2016:02	BACEN	158

Note: Variables descriptions, database, time periodicity and specification.

X13- ARIMA. For inflation expectations ($E_t[\pi_{t+12}]$) we use the Central Bank reports based on the FOCUS estimates for 12 next month's inflation, but since these data have daily frequency we select the median for each month, seasonally adjusted.

For the gap variable (x_t), which is often treated as the marginal cost of the economy, we test four proxies based on the works of Gali and Gertler (1999) and Sims (2008): 1) The Brazilian industrial output; 2)The Central Bank of Brazil Economic Activity Index (IBC-Br); 3) The share of total wages in output and 4) The unemployment rate. We calculate (1,2) as the difference between the production index, seasonally adjusted using the X13- ARIMA, and its potential value obtained through the Hodrick-Prescott filter.(3) is constructed as the ratio between the effective wage mass of the economically active population and the nominal GDP, seasonally adjusted using the X13-ARIMA method. Finally, for (4) unemployment (u_t), we use the monthly open unemployment rate, calculated by IBGE for the metropolitan regions, seasonally adjusted by the X13-ARIMA method and submitted to the Hodrick-Prescott filter. For changes in the prices of the non-produced input, (Δv_t), we follow Mazali and Divino (2010) and calculate the percentage change in the nominal exchange rate between real and dollar, but for a six-period interval, according to the following formula $\Delta v_t = 100ln\left(\frac{v_t}{v_{t-6}}\right)$.[6]

The following variables are endogenous: gap variable, inflation expectations and exchange rate. In this context, following Blanchard and Galí (2007), Mazali and Divino (2010), Chorteas and Panagiotidis (2012) and Boz (2013) , all these variables were instrumentalized using two inflation lags and two lags of the variable itself, except in the case of

[6]All variables, after treatments, are stationary. The tests used were ADF, ADF-GLS, PP and KPSS.

inflation expectations that the literature suggests the use of only one lag. [7]

In addition, to reinforce the use of quantile regressions, we present below the heteroscedasticity tests for partial regressions between inflation and the other variables:

Table 2.2: Heteroscedasticity - Breusch-Pagan Test

Variable	**Statistic**	**p-value**
Lag	3.501	0.045
Expectations	7.115	0.007
Ind. Product	0.067	0.790
IBC-Br	0.001	0.950
Wage Mass	1.301	0.253
Unemployment	1.001	0.317
Exchange Rate	8.934	0.002

Note: Breusch-Pagan test, studentized, to detect heteroscedasticity. H_0: There is no heteroscedasticity.

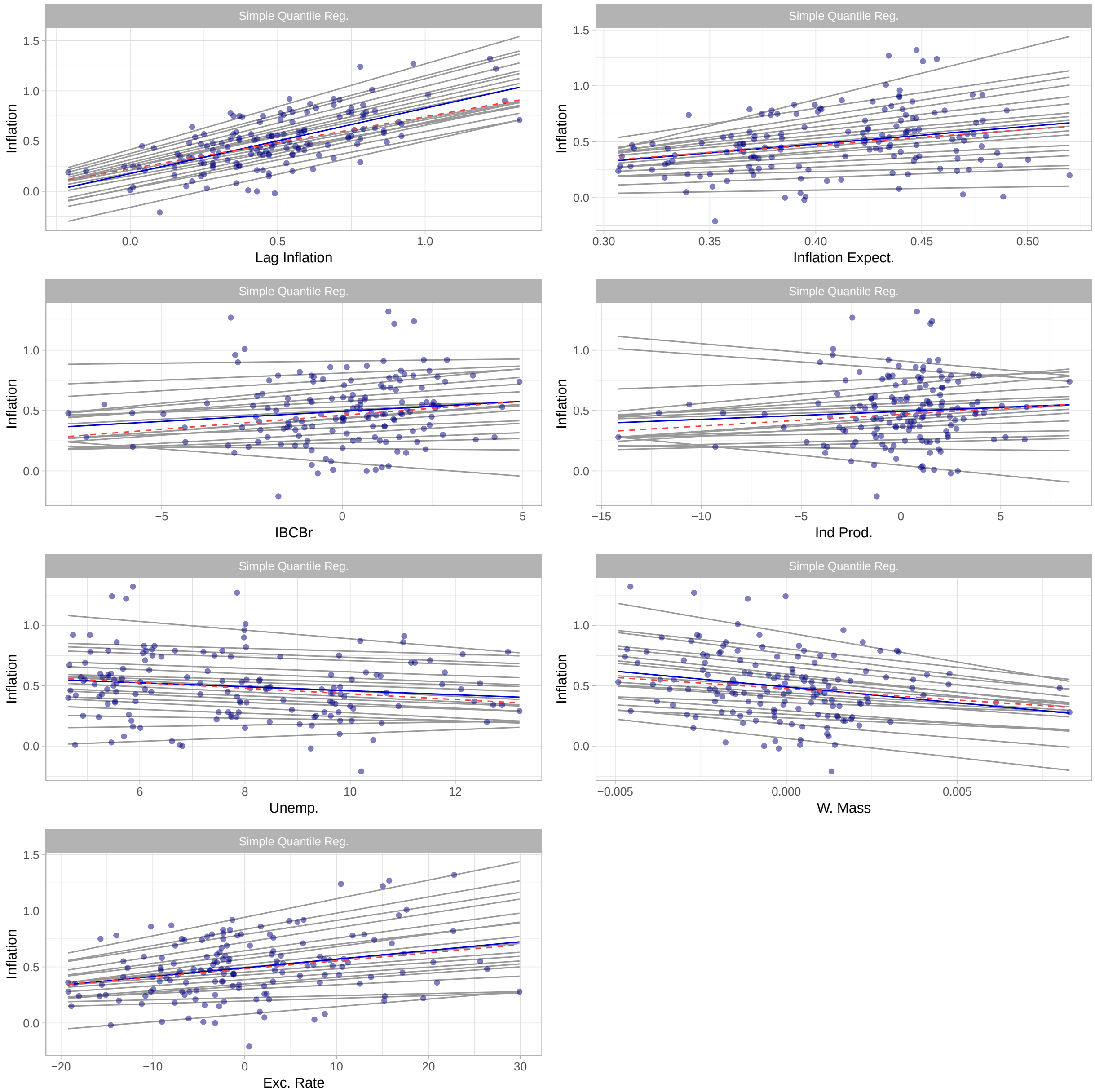
From the results, there seems to be heteroscedasticity in the lagged component, expectations and exchange rate. However, for real side proxies, the hypothesis of homoscedasticity was not rejected. Furthermore, we estimate one-dimensional quantile regressions to illustrate the heteroscedastic relationship between inflation and the other variables used in the proposed specifications: expectations, lagged inflation, an economic activity gap variable and nominal exchange rate. In Figure 2.2 we consider the quantiles $\tau = \{0.05, 0.10, 0.15, ...0.90, 0.95\}$. The blue line represents the OLS estimation, the red line the QR estimation in the 0.50 quantile and the gray lines represent the other estimated quantiles.

Initially, we observed that for all variables the estimates in the mean and median already differ from each other. Expectations, the lagged component, and the exchange rate appear to be positively related to current inflation, especially at the higher conditional quantiles of the inflation. On the other hand, wage mass has a negative relationship with current inflation. Finally, for Industrial Product, IBC-Br, and unemployment there is an ambiguous behavior depending directly on the quantile analyzed.

In the next section we develop the multiple econometric analysis, with the respective tests and inference.

[7] From the Cragg-Donald and Kleibergen-Paap tests, we reject the null hypothesis that the chosen instruments are weak for endogenous variables.

Figure 2.2: Fitted Lines



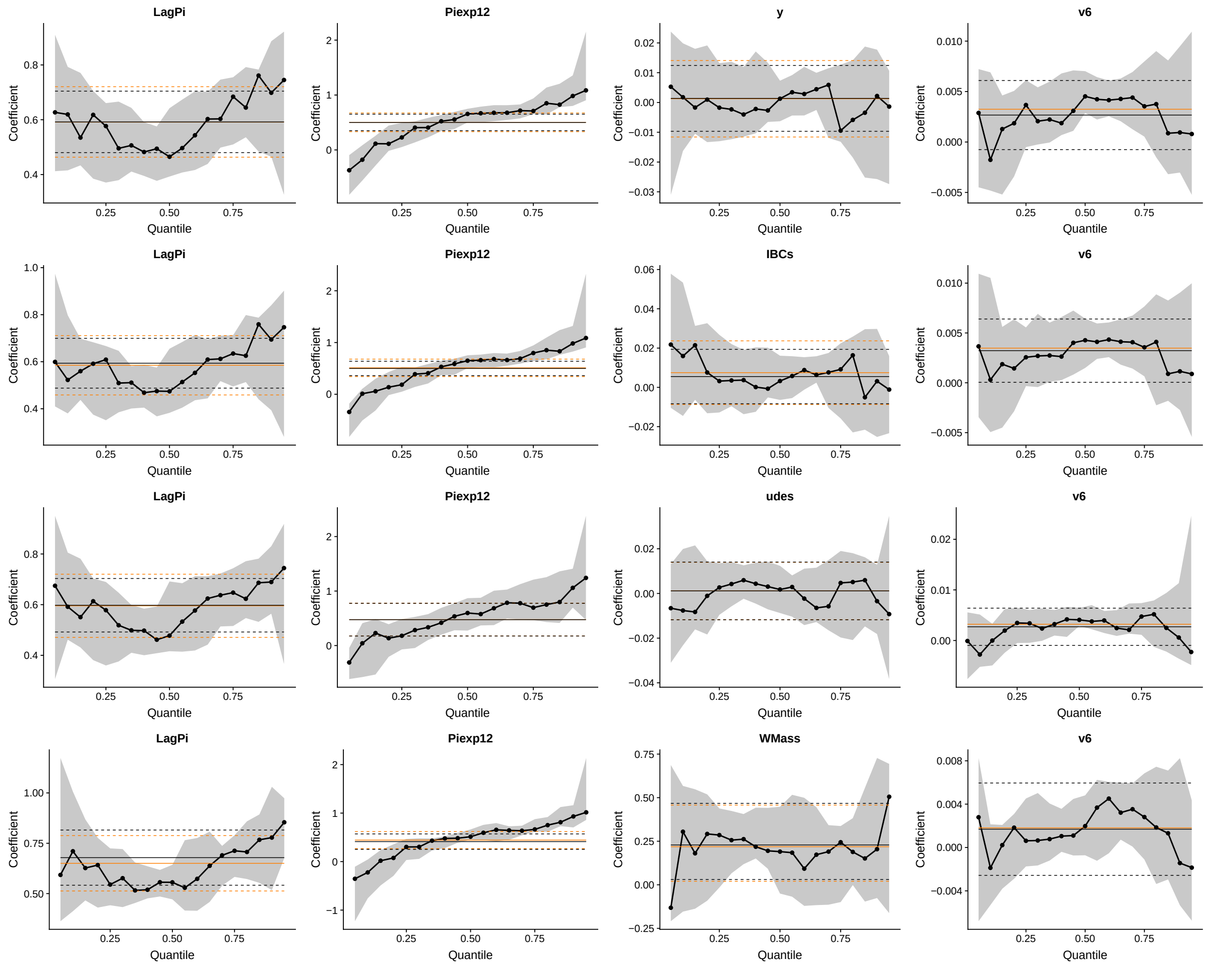
Note: Partial QR estimations.

2.4 Results

2.4.1 Two Stage Quantile Regression

The comparison values are the 2SLS and GMM instrument estimates. All standard error estimates and the covariance matrix of the regressions were based on the moving blocks bootstrap method with 10,000 replications.

Figure 2.3: Quantile Regressions



Note: Estimated coefficients: QR, 2SLS and GMM.

In Figure 2.3, the black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. In addition, the horizontal lines represent the 2SLS (black) and GMM (orange) values with their respective confidence intervals (dashed black/orange lines).

According to the 2SLS and GMM instrument estimates, we observed that on average the coefficients of inflation expectations and lagged inflation are statistically significant, with values close to 0.95 and 0.50 respectively. The variable that captures the exchange pass through was significant at 10%. However, the *proxies* used to represent the real side were not significant.

Quantile Regression results show that the marginal effects of the explanatory variables on the inflation rate may oscillate at various quantiles. The *backward-looking* component is significant, but always remains in the mean estimations (2SLS and GMM) confidence intervals.The *forward-looking* component is significant from the fourth quantile (20%) onwards. The coefficient increases in large deviations from the 2SLS and GMM values. For the pass-through component, the behavior between quantiles seems stable within the average estimates.

The estimated coefficients for the gap also vary, diverging about the positive or negative impact at different quantiles, but are not statistically significant in most of distribution. indicating a possible absence of effects on inflation behavior. The proxy that stands out (and has the best significance performance) is the wage mass.

The wage mass (second proxy for the gap) is significant at the 10% level in the 2SLS and GMM estimates. In quantile regressions, the variable presents significance from the 25% to 50% quantiles, with small deviations from the mean value. Thus, even with little expressive variations, it seems that wage mass has significance in a larger number of quantiles.

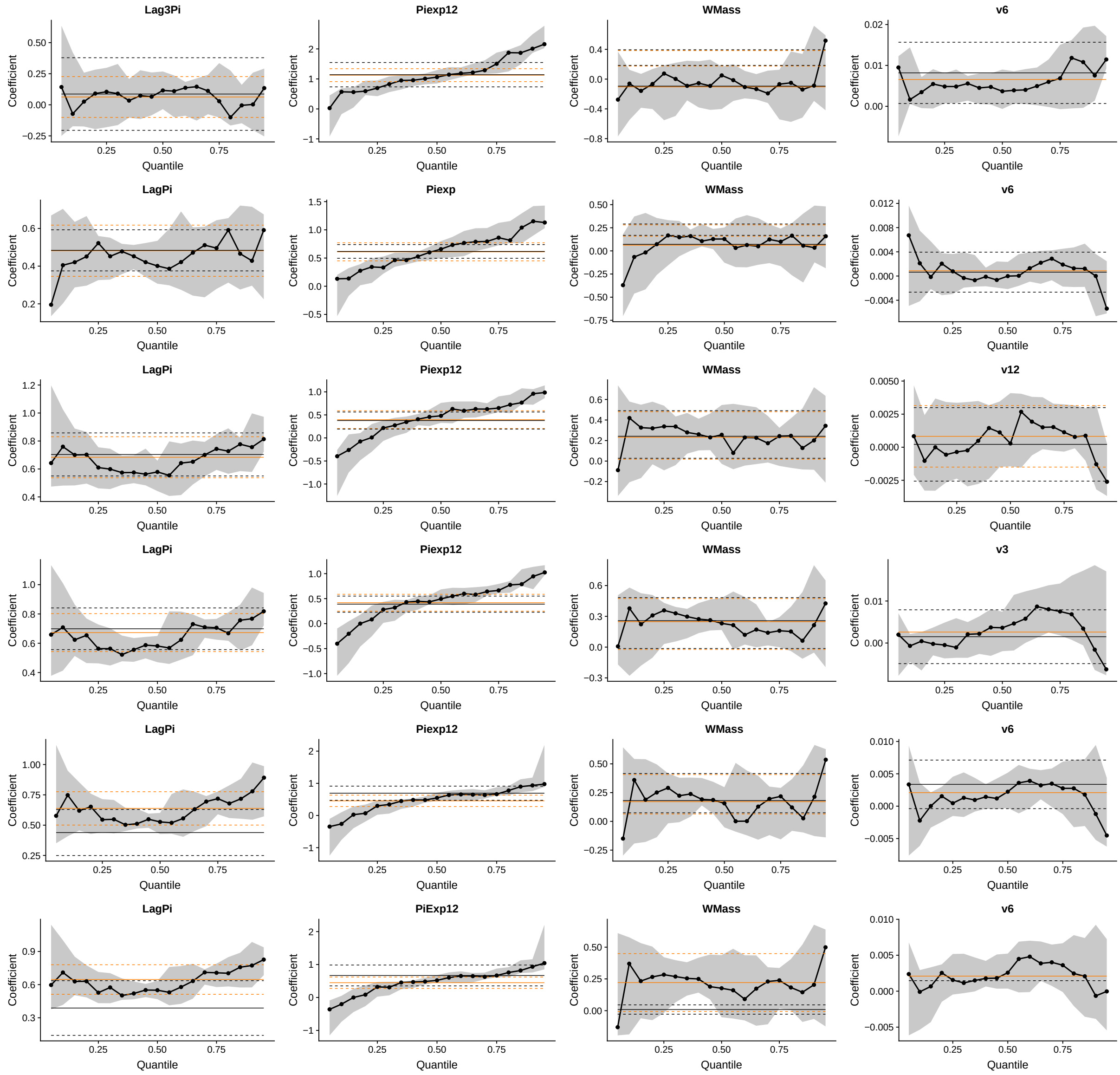
Briefly, the first part of the analysis provided evidence that the backward-looking and forward-looking components appear strongly significant in the Hybrid Phillips curve estimates, with few differences between estimated versions. The quantile model shows that there is higher coefficients of backward-looking component only at the lower tail of the current inflation distribution (5% - 30%). From these results, we can conclude that the inflation response, conditional on expectations, is not symmetrical. Thus, a positive inflation shock when expectations are high causes a higher inflation than when expectations are smaller.

2.4.2 Robustness

Finally, before estimate the conditional density functions, to validate the findings,we performed some robustness tests:

(a) *Inflation Lag 3 months;*
(b) *Inflation Expectations 1 month ahead;*
(c) *12-month exchange pass-through;*
(d) *3-month exchange pass-through;*
(e) *Extension of instrument lags;*
(f) *Quarterly data.*

Figure 2.4: Robustness



Note: Estimated coefficients: QR, 2SLS and GMM.

With these tests, we try to make the model more flexible and show that the results remain even when we make some changes. In the first one (a) we try a longer lag order. Second, (b), we reduce the time horizon of expectations, to understand the behavior of the forward-looking component in small horizons. In addition, we change the lags of the exchange variable, since as we can see in the works of Bogdanski, Tombini and Werlang (2000) and Mendonca and Torres (2015) there is no consensus about the duration of the Brazilian pass-trhough, especially in different periods: in (c) and (d) we extend/reduce.

Following, in (e) we increase the extension of the instruments in the first stage, seeking to capture some possible extensive autoregressive behavior in the data. Finally, in (f) we use quarterly data, following Mazali and Divino (2010) and Correa and Minella (2010).

Some results are interesting: The inclusion of a longer lagged component does not appear to be statistically significant for the analyzed data, as the increase and decrease in exchange pass-through has very small effects when compared to the basic model. In addition, the results of the original model seem to hold even as we change the data frequency. Basically, the asymmetric behavior of expectations and the significance of the wage mass remain after the robustness tests.

It is important to justify that we estimate the conditional density functions with the data at monthly frequency. We adopt this strategy because the larger the data set, the greater the accuracy of the estimated conditioned quantile coefficients and the greater the possibility of perceiving asymmetries in the conditional distributions.

2.4.3 Density Estimation

We try to verify if higher inflation expectation is associated with higher inflation dispersion. We construct the conditional distributions of inflation based on the estimated quantile regressions using high ($E_t[\pi_{t+1}]_{95\%}$) and low ($E_t[\pi_{t+1}]_{05\%}$) values of inflation expectations and keeping the other variables in the median. In this estimation, we use the most representative quantile model: Inflation at (t-1), expectations 12 months ahead, wage mass and exchange rate with 6 months difference.

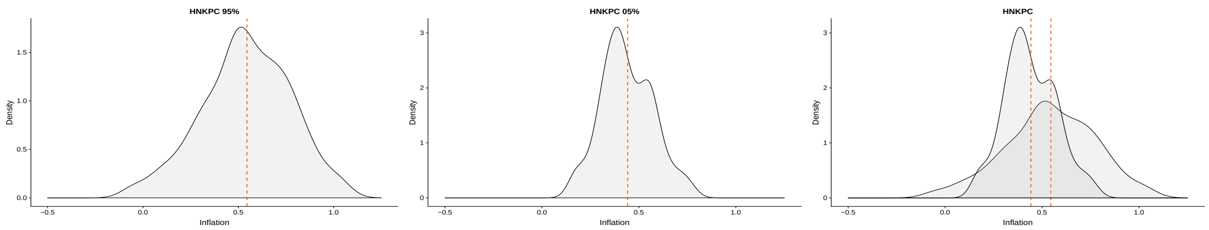
Table 2.3: Conditional Density

$Q_x(\tau)$	$\hat{\mu}(\hat{\pi}_t\|Q_x(\tau))$	$\hat{\sigma}(\hat{\pi}_t\|Q_x(\tau))$	$\hat{R}(\hat{\pi}_t\|Q_\pi(\tau))$	$\hat{\zeta}(\hat{\pi}_t\|Q_x(\tau))$
$E_t[\pi_{t+1}]_{95\%}$	0.541	0.231	1.088	0.219
$E_t[\pi_{t+1}]_{05\%}$	0.439	0.133	0.616	0.542

Note: μ represents the mean, σ the standard deviation, R the range and ζ the asymmetry.

In Figure 2.5, we show the separate graphs of the two estimated conditional densities. The density on the left indicates the conditional distribution of current inflation when inflation expectation is high (95th unconditional percentile). At the center we have conditional density when expectations are low (05th unconditional percentile). And finally, in the third figure, we present the cross conditional distributions, for a better visualization of the dispersion and asymmetry in both cases. The dotted vertical line represents the value of the point estimate in the case of an OLS model.

Figure 2.5: Conditional Denstities



Note: Conditional Density.

We can see that $\hat{\sigma}(\hat{\pi}_t|Q_\pi(\tau))$ and $\hat{R}(\hat{\pi}_t|Q_\pi(\tau))$ are different, according to expectations level. Furthermore, the standard deviation is lower in periods of low expectations. The results provide evidence that the Phillips curve adequately captures the asymmetry of the forward-looking component. This means that we expect a greater variability in the values of conditional inflation, when expected inflation is higher.

This result shows evidence of the hypothesis proposed by Coibion, Gorodnichenko, Kumar and Pedemonte (2018), higher inflation expectations can induce higher current inflation volatility. These conclusions are also in line with the work of Minella and Muinhos (2003), Mendonca and Santos (2006) and Mendonca and Torres (2015), which argue that the central bank's credibility should be one of the best structured foundations for conducting monetary policy, since well-anchored expectations lead to further price stabilization.

2.5 Conclusions

The main objective of this essay, besides the investigation of asymmetry in Brazilian price dynamics, is to advance in: i) Verify the best real activity proxy; ii) Compare the coefficients of the backward and forward looking components and iii)Understand whether low/high expectations are related to lower/higher dispersed current inflation.

We found that the wage mass was the best proxy. Significant at the 10 % level in the 2SLS/GMM estimates and at the 5% level in the QR estimation between the 15 % and 30 % quantiles. Furthermore, there are asymmetric effects of the forward-looking component on current inflation, with few differences in the coefficients between the estimated versions. In the extreme tails of current inflation distribution, the lowest (less than 25 %) and the highest (greater than 75 %) quantiles, the forward-looking coefficient oscillate and fall outside the 2SLS confidence interval. On the other hand, for lagged inflation, we can not reject the hypothesis of equality between the QR and 2SLS estimates, from 5% to 95% quantiles.

Finally, our results show that $\hat{\sigma}$ and $\hat{R}$ are lower for periods of low expectations. Reinforcing the evidence of asymmetry in the Brazilian New-Keynesian Phillips Curve, mainly through expectations. Our findings indicate that theoretical models can still advance in order to incorporate and to explain the reasons behind the patterns we encounter.

Chapter 3

Revisiting Institutional Quality in Brazil

3.1 Introduction

Studies on income differences between countries are explored theoretically and empirically. In the first case, authors such as (Solow (1956),Romer (1986) and Mankiw (1992)) consider the factors(inputs) that directly determine income growth, such as the amount of physical and human capital. They work on micro-based models for the construction of growth accounting equations. Typically, the marginal product of factors is calculated considering market prices and then sequentially combined with current factor quantities to obtain average estimates of each factor's contribution to income differences between countries.In the second branch (represented by authors such as Acemoglu,Johnson and Robinson (2002), Rodrik, Subramanian and Trebbi (2004),Glaeser, La Porta, Lopez-de-Silanes and Shleifer (2004) and Acemoglu (2009)), the focus is on possible additional determinants of income differences between countries, such as: institutions, geography, history and culture.

Following the rise of the "New Institutional School" (Williamson (1985), North (1990) and Coase (1998)), the role of institutions gradually became prominent. The importance of an adequate institutional organization, parallel to the macroeconomic conjuncture, began to permeate the economic debate about growth. But this discussion is not unprecedented in economics, since Adam Smith already showed concerns about the implications of institutions in the economic process. There was an arduous path before the consolidation of institutions as a new approach of economic growth, mainly because of the non-consensus of the term "institution". This concept may not be clearly defined and have several fields of analysis, therefore we seek to analyze the institutions that represent the agents' behavioral guidelines. In other words, in this essay the central concern is with the institutions that provide economic growth (what Hall and Jones (1999) call social infrastructure), as laws, rules, regulations, and policies that affect incentives.

If we consider that institutions have many dimensions, their effect on income can occur through many channels. Some works try to overcome these problems: Knack and Keefer (1995), Acemoglu,Johnson and Robinson (2001),Acemoglu,Johnson and Robinson (2002) and Hall and Jones (1999). They try to find appropriate proxies to measure the effects of social infrastructure on cross country differences of income per capita. In the Brazilian case, we highlight the contributions of Menezes-Filho, Marcondes, Pazello and Scorzafave (2006), Naritomi,Soares and Assuncao (2012) and Nakabashi,Pereira and Sachsida (2013), in an attempt to measure the impact of institutions.

Attempts to estimate the relationship between growth and institutions face two major problems: i) Practical: how to measure institutions, or the social infrastructure, of a particular region. ii) Conceptual: how to get accurate estimates of regression parameters, given the difficulty in controlling for all possible sources of income variation.

We focus on the second problem, a common challenge in the applied analysis of economic growth: infer causal relations. Hence, in the cross-country analysis, natural experiments can help to relate chronologically the direction of effect among the variables. Some studies (see Acemoglu,Johnson and Robinson (2001)) seek to understand the institutional origins (historically) and the process responsible for their persistence. It is these differences in the ”rules of the game” that would account for much of the growth distortions.

There is an extensive literature that addresses these institutional historical aspects and indicates that institutions really matter for economic growth (see Acemoglu,Johnson and Robinson (2001),Acemoglu,Johnson and Robinson (2002), Rodrik, Subramanian and Trebbi (2004), Glaeser, La Porta, Lopez-de-Silanes and Shleifer (2004), Acemoglu and Robinson (2008) and Acemoglu,Johnson, Robinson and Yared (2008)). Basically, any variation in other factors (explained based on the exogenous past variable) can be attributed to the causal effect of the latter on the others. Simplifying, this is the procedure that we execute through the use of instrumental variables. Then, besides seeking a good proxy for the institutions, it is necessary to address an econometric problem constantly reported in the literature: endogeneity. Therefore, the choice of appropriate instruments (not weak), which capture historical disparities, can aid the estimations and provide reliable results on the differences in income distribution among regions.

The effect of institutions on economic growth can be thought for both countries and regions, especially within a country with continental dimensions. In Brazil, there are still few studies dedicated to exploring the institutional effects on regional growth (Menezes-Filho, Marcondes, Pazello and Scorzafave (2006), Naritomi,Soares and Assuncao (2012) and Nakabashi,Pereira and Sachsida (2013)), taking into account historical instruments of current institutions. More specifically, studies that rely on historical instruments to explain current institutional quality are lacking.

As a major difference from previous work, we tested different instrumental variables from the 1872 census. The main purpose of this essay is to verify possible historical roots of current institutions. Specifically, it is verified whether the information present in the 1872 Census relates to the quality metric of current institutions. This comparison is made at the municipal level, using the concept of Minimum Comparable Areas (AMC), which allows comparing municipalities in 1872 with the current ones. The following 1872 Census information is used: Judges, Military, Demographic Density and Land and Capital Holders. This data source has already been used in the work of Menezes-Filho, Marcondes, Pazello and Scorzafave (2006), but we think the inclusion of these new variables, not yet evaluated in previous studies, is relevant as they may well represent the inequality of wealth and political representation in 1872.

As an additional exercise, we use the previous estimates as the first stage to verify the impact of institutions on per capita GDP differences between the locations studied. In this second stage possible asymmetries will also be explored through the use of quantile regression. Considering the Brazilian geographic extension, it is believed that asymmetries may exist, due to regional diversity. The use of quantile regression would allow us to model these asymmetries, indicating new aspects of the relationship between institutions and income differences.

The next section is devoted to a brief analysis of the theoretical and empirical references that support the proposed analysis. In section 3 we present the method used and, finally, in sections 4 and 5, we analyze the results of the estimated models and the respective conclusions obtained.

3.2 Theoretical and Empirical Evidence

3.2.1 How to Define Institutions?

Social norms are at the root of the new institutional economy. In this field , some authors are dedicated to the study of the formal norms (laws) and another to the informal norms (culture). These elements (patterns of social behavior, laws and culture in a country) are defined as the "rules of the game". In the decision-making process, for example, a fast-food company is subject to (formal) labor laws to hire new employees and to regional consumption habits (informal). As an example, the McDonald's in India only sells hamburgers that are not made with beef. The rules of the game are important since it allows better coordination of the agents and greater efficiency of the processes, affecting the cost-benefit relationship in the decision-making environment.

In a seminal work, Veblen (1899) defined institutions as the common and predictable patterns of social behavior, including commonly shared actions and habits. Hayek (1973) also had influence over some "institutionalist economists of Austrian tradition". For them, institutions are defined as recognized practices of a society, which are usually appropriate to some circumstances. Williamson (1985) differentiated structures of authority from the rules of the game. For him, authority structures refer to transaction units (firms and people), basic units of economic activity, and the rules of the game would be the institutions to which these transactions between agents are conditioned. North (1990) directs his work to the question of the efficiency of institutions, raising the hypothesis that societies with more developed and efficient institutions are richer.Coase (1998) is concerned with the study of how institutions affect transactions and the costs that can be generated or reduced by them. The common point of these analyzes is that all authors indicate that good institutions can facilitate economic growth.

3.2.2 Institutions and Growth

We can expect institutions to affect cost-benefit and risk calculation by agents. This is because the set of laws and cultural habits determine, even indirectly, the business opportunities and the guarantee of property rights in the economy. Consequently, through this channel we expect the decision-making process to be affected and, ultimately, to affect economic growth.

Empirically, wealthier countries are able to maintain stronger and more stable institutions. This means that we must be aware of the problem of reverse causality in studies that relate institutions and economic growth, whatever the direction of dependence. Thus, one of the challenges of the literature is to deal with simultaneity, which occurs when an explanatory variable is determined simultaneously with the dependent variable. This is a common fact in econometric models that seek to show the relation between institutions and per capita income. As these problems can distort coefficients, much of the literature uses instrumental variables in cross-country analysis, finding exogenous sources in history and geography variables.

Hall and Jones (1999) test the hypothesis that institutions would be the root cause for differences in countries' per capita income levels. The authors use Penn World Table and Global Demography Project data for 127 countries in 1988. As a proxy for institutions, the authors' combine two indexes that measure, respectively, the quality of government policies (law and order, bureaucratic quality, corruption, expropriation risk and government repudiation of contracts); and a measure of openness to international trade. Moreover, as instruments, they adopt the distance from the equator, the fraction of the population that speaks English and the fraction of the population that speaks other European languages. The results show that the better the institutional index, the higher the per capita income level. Also, controlling for endogeneity, much of the difference between income would be explained by institutional levels.

In the group of seminal papers that investigate the institutional aspect in the historical field, linking institutions and colonization, we have Engerman and Sokoloff (1997), La Porta,Lopez-de-Sinales,Shleifer and Vishny (1998) and Acemoglu,Johnson and Robinson (2001). Basically, the focus is on the process of colonization in the sixteenth century (European expansion). According to the authors institutions are an important determinant of long-run economic development.

Engerman and Sokoloff (1997) examine the developmental trajectory of American countries that were colonized by European nations, in similar periods. They use historical data for the colonies and colonizers from 1500 to 1989. The main hypothesis is that the type of colonization was directly influenced by the endowments of resources (colony) and consequently would define institutional maturity. The results indicate that the initial differences in the levels of wealth, human capital and political influence, among the different societies of the American continent, could be explained by the initial appropriations. Basically, in the colonies of exploitation with the biggest inequalities, the institutions were designed to protect the elites, impacting on the future delay of the country.

La Porta,Lopez-de-Sinales,Shleifer and Vishny (1998) investigate the effect of legal rules, which protect investors' rights, on financial (and indirectly economic) development. Exploring data from the International Country Risk Guide, Word Bank and Moody's (mostly averages between 1982 and 1995), the authors use as a proxy for institutions the protection of investor rights and as an instrument the difference between legal systems based on British "common law" and Roman "civil law"[1]. The results show that countries with legal systems based on common British law offer better protection to investors than countries with legal systems based on Roman civil law.

Acemoglu,Johnson and Robinson (2001) present an empirical study about the effect of institutions on economic performance in European colonies. The main hypothesis is that the policies adopted in the colonization period caused differences in the institutional quality of the colonies. Moreover, the authors construct the argument that in the countries with the most lethal diseases, for the Europeans, and the small influx of immigrants, settlers had no incentive to establish rigid rules of property law and instead set up institutions to extract maximum resources from the colonies. Analyzing World Bank data for 75 countries the authors use the Land Expropriation Rate (1985-1995) as a proxy for current institutions, instrumentalized by the settler mortality rate (from 1817 to 1848). In the first stage, the authors find a negative relationship between the mortality rate of colonizers and the quality of current institutions. In the second, estimates indicate that institutions have a strong positive effect on current per capita income, attesting some temporal persistence.

But while the literature on the role of institutions strengthened, there was a debate about the real power of institutions when compared to other factors such as human capital, geography and international trade.

Glaeser, La Porta, Lopez-de-Silanes and Shleifer (2004) discuss the contributions of institutions and human capital to growth between 1960 and 2000. They evaluate two hypothesis: (i) Democracy would lead to better maintenance of property rights, which in turn allow investments in physical and human capital to boost growth. (ii) The need for investments in human capital would be a prerequisite for institutional improvement and consequently to economic growth. They analyze three sets of data for institutions: i- Data used by Knack and Keefer (1995),Hall and Jones (1999) and Acemoglu,Johnson and Robinson (2001), from the International Country Risk Guide; ii- Data explored by Rodrik, Subramanian and Trebbi (2004) and iii- Polity IV data set. Initially, Glaeser, La Porta, Lopez-de-Silanes and Shleifer (2004) indicate that some of the instrumental variables used in the literature are flawed. Furthermore, the authors find evidence that institutions matter, but human capital seems to be a more basic source of economic growth. They observe that some countries are able to overcome the poverty through good policies pursued by dictators. They also mention that initial levels of education (human capital) can lead to sequential increases in the institutional level.

[1]The difference between is that in common law countries, case law is of primary importance, whereas in civil law , codified statutes predominate.

Sachs (2003) propose a counterpoint to the dominant view that institutions were one of the prime causes of growth. For income data in 1995, the author uses the following instruments: i-The share of a country's population in temperate ecozones, based on the Koeppen-Geiger ecozone classification system(Mellinger, Sachs and Gallup (2000));ii-Mortality rates of British soldiers and other populations in the early 19th century(Acemoglu,Johnson and Robinson (2001)) and iii- An instrument for malaria risk that controls causation not only from malaria to income but also from income to malaria. The author concludes that the institutions themselves would not play a relevant role and, consequently, the main effects would be attributed to geography (through malaria transmission).

Acemoglu,Johnson and Robinson (2002) develop the inversion of fortunes argument, contrary to the hypothesis that the time-invariant geographic effects (climate and disease) would directly affect income levels, making prosperous nowadays nations which were relatively rich in 1500. From this inversion, Acemoglu,Johnson and Robinson (2002) explore the institutional perspective. Using urbanization and population density as proxies, for both cases the authors find evidence that the countries, in 1500, with the highest incomes are now the least developed. Moreover, the ratio remains approximately stable even controlled by geographic factors, such as distance from the equator and temperature. Basically, they conclude that history was rather important to shape the institutions, which in turn determine the distinct growth between countries.

Rodrik, Subramanian and Trebbi (2004) develop a study focused on the explanatory power of institutions compared to the geography and international trade. The authors make estimates simultaneously using the set of instruments for institutions (mortality rate of the settlers) and trade (gravity equation for bilateral flows), from the papers of Acemoglu,Johnson and Robinson (2001) and Frankel and Romer (1999). The results show that once the quality of institutions is controlled, geography has a small effect on income [2].

Acemoglu,Johnson and Robinson (2005) construct a theoretical model on the dynamics of institutions and the effects on income. The authors discuss the circumstances under which institutions are chosen and the mechanisms through which political institutions and distribution of resources influence economic institutions and growth. While political institutions determine "*de jure*" (formal) political power in society, the distribution of resources influences the allocation of "*de facto*" (effective) political power. These two sources of political power, in turn, affect the choices of economic institutions and the future evolu-

[2]Trade, by itself, is related to institutional aspects. Thus, although trade is relevant, its intensity is also determined by institutional aspects, which justifies its insignificance after controlled by institutional variables.

tion of political institutions themselves. Furthermore, economic institutions determine the performance of the economy, both in terms of growth and in terms of the distribution of resources in the future. Although economic institutions are fundamental determinants of economic performance, they are endogenous and shaped by political institutions and the distribution of wealth in society.

Acemoglu,Johnson, Robinson and Yared (2008) hypothesize that the evidence supporting the modernization theory [3] would not be significant, even with a positive correlation between the variables. The authors use data from the Penn World Table, Maddison and Policy IV between 1500 and 2000 (with intervals of 50 years), between 1875 and 2000 (with intervals of 25 years) and between 1960 and 2000 (with intervals of 5 years). For all temporal cutbacks no evidence was found to support a causal relationship between per capita income and democracy (political institution), using multiple methods (IV, FE, GMM, among others). Consequently, the authors conclude that historical socioeconomic events at "random" times would affect democracy more forcefully than income. However, in a more recent paper, Acemoglu,Naidu, Restrepo and Robinson (2017) show that the opposite relationship is valid and significant, democracy (as a political institution) affects the growth rate of several countries.

Finally, in recent years there has been substantial growth in the debate about the effects of income inequality on economic growth, mostly drawn by Piketty (2014) work. However, Acemoglu and Robinson (2015) argue that the general laws of capitalism, proposed by Marx and reinforced by Piketty, would not be useful to understand the past or predict the future of inequality in the world, since they do not take into account public policies, institutional changes and technological advances. The authors combine data from Piketty, OCDE, Madison and Pen World Table, from 1870 to 2012 with 10-years intervals, covering 27 countries. Through regressions they counter a central argument of Piketty's work: the difference between the real interest rate and the growth rate would explain inequality in the last century. Moreover, the authors show that the focus on the 1% percentile may lead to imprecise results, by ignoring some socioeconomic changes that countries have experienced in history.

After this brief exposition about the importance of the institutions, as a factor of growth, we focus on the main works that deal with this problem in Brazilian regions.

[3] Lipset (1959) argues that democratic regimes would have a longer duration in richer countries, so income would generate democracy.

3.2.3 Institutions and GDP in Brazilian Regions

There are few papers that analyze the relationship between income and institutions in Brazil: Menezes-Filho, Marcondes, Pazello and Scorzafave (2006), Naritomi,Soares and Assuncao (2012) and Nakabashi,Pereira and Sachsida (2013).

Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) investigate whether the hypotheses presented by Acemoglu,Johnson and Robinson (2001) and Engerman and Sokoloff (2002) are valid to explain income differences across Brazilian states. The authors use data from multiple sources to construct the explanatory variables: report of conselheiro Velloso de Oliveira, 1872 census, Statistical Yearbook of Brazil and 1920 census. Moreover, for institutional quality, Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) use the enforcement of labor laws (the ratio between the number of companies assessed and the number of companies audited) for each state in 2005, following the work of Almeida and Carneiro (2005).

The correlation analysis indicates some important relationships: GDP per capita seems to be positively correlated with current institutions. But the relationship between the proportion of slaves and current institutional quality, even if theoretically plausible, does not show stability when tested statistically. Moreover, the proportion of illiterates in 1872 is negatively correlated with current institutions (it is expected that greater instruction in the past will directly affect the institutional quality nowadays) and the proportion of voters in 1910 appears to be positively correlated with the quality of institutions (emphasizing the temporal effect of political institutions). Finally, the number of foreigners per state also appears to be positively correlated with institutional quality, indicating that in states with the highest concentration of immigrants in 1920 the institutional quality is better today.

Besides, the authors revisit the argument that geography would determine the design of the initial institutions. Using historical variables as proxies for institutions in the past, Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) show that each of them has a significant relation with latitude (geographic variable). Finally, the authors estimate a regression model with instrumental variables (IV) in two stages. In the first stage regress current institutions against historical proxies and in the second the per capita GDP against institutions 'predicted by the past'. The results, as expected, indicate that better institutions in the past will determine better institutions today and then higher per capita income.

Naritomi,Soares and Assuncao (2012) develop a study with two important advances: i- They analyze the the determinants of local institutions at the municipal level; ii- They present three dimensions of local institutions. The authors hypothesize that variations among municipalities would be directly associated with the colonial history (sugar cane and gold cycles), distinct in different parts of the country. These cycles were chosen because they are the periods of the greatest expansion in Brazilian colonial history.

One of the greatest innovations of the work is to present two new historical variables, gold and sugar cane production boom, which reflect the degree of involvement of the municipalities with the respective cycles. In short, municipalities up to 200 km away from those directly involved with the gold/sugar cane cycle, the others do not. The institutional variables are divided into three levels: (i) Gini coefficient of the distribution of land in 1996, from the Brazilian Agricultural Census, (ii) Index of governance practices calculated by the Brazilian Census Bureau and (iii) Access to the justice system, through the index proposed by the Brazilian Census Bureau [4]. Moreover, a number of other controls are used: years of study, distance from Portugal and latitude, among others.

Using regressions, for more than 4,000 municipalities, the main results show that the regions affected by the extraction and with a strong influence of the Portuguese government present the worst outcomes today. In other words, the sugar cane cycle appears to have worsened the concentration of land and the gold cycle is negatively correlated with access to justice and current government practices.

Nakabashi,Pereira and Sachsida (2013) focus on institutional disparities among Brazilian municipalities as the engine of income per capita differences. The authors support the argument that institutions matter for income, but the channel of transmission of this effect would be through the distribution of political power, the generation of opportunities and capital accumulation.

They use the Institutional Quality Index of the Municipalities (IQIM), elaborated by the Brazilian Planning Ministry, as a proxy for institutions. Furthermore, seeking to overcome the endogeneity problem, institutions are instrumentalized through the following variables: latitude , average annual temperature, average annual rainfall, capital per capita and human capital per capita. For the sample of 5,507 Brazilian municipalities, in 2000, the results indicate that the institutional level is important to explain the income differences. Numerically, each point of increase in the IQIM affects per capita income in approximately U$1000. Moreover, institutional quality seems to be more determinant in large municipalities and human capital in smaller. Finally, the estimates show that geogra-

[4] Since there was no formal municipal judicial system in Brazil, court or justice commissions in a municipalities were either related to the local executive or to the state judicial system.

phy is important because it interacts with history and can determine the initial formation of institutions.

3.3 Empirical Startegy

We use municipal data from multiple sources: 2000 census from the Brazilian Institute of Geography and Statistics (IBGE), 1872 census from the Brazilian Institute of Geography and Statistics (IBGE) and digitalized by Cedeplar/UFMG (Research Group in Economic and Demographic History), Institute of Applied Economic Research (Ipea) and Planning, Budget and Management Ministry. We follow Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) and Nakabashi,Pereira and Sachsida (2013), but the main difference of our study is that besides the use of a larger number of possible instruments, from the 1872 census, we focus on possible asymmetric effects of the institutions on the income of the Comparable Minimal Areas (AMC).

The AMCs represent a strategy to fix the space unit in a period of interest. Even with the changes and dismemberments of municipalities, the units are delimited and remain fixed over the years. This methodology, which consists of 18 steps ranging from the correction of the municipal names and territorial disputes to the match of the regions for the periods of interest[5], was developed by Ehrl (2016) and applied by Komatsu, Menezes-Filho and Oliveira (2018) [6]. In 2000, we reach a total of 485 AMCs, but with the exclusion of missing regions, we work with a total of 477.

In our database, the municipal institutional quality indicator (IQIM) is a central variable. The indicator results from the sum with equal weights of three sets of sub-indicators: *Degree of Participation;Financial Capacity; Management Capacity.* The degree of participation seeks to measure the participation of the population in the municipal administration, based on the number of municipal councils and their characteristics. Financial capacity represents the number of inter-municipal consortia, the ratio of the municipality's debt to its current revenues, net of personnel expenses and per capita real savings. Moreover, the management capacity indicates IPTU values, the degree of tax-payment and number of management and planning instruments used by the municipalities. Furthermore, we use GDP per capita, Human Capital, Latitude, Annual Rainfall and Demographic Density.

[5] Author measure the number of origins or destinies for each municipality that is separated or annexed between the start year and the interest census.

[6] The authors examine the power of the elite in the democratic process and the evolution of educational inequality by ethnicity in Brazilian municipalities.

Following, Menezes-Filho, Marcondes, Pazello and Scorzafave (2006), the variable that represents the percentage of slaves is used since this represents in large part the inequality of wealth and political representation, which continued for decades, even after its abolition. However, we adopted slightly different empirical strategy and we also test the following proxies for inequality of wealth and political representation in 1872 (historical institutions):(%) of Immigrants in Total Population, (%) of Judges in Total Population, (%) of Military in Total Population, Demographic Density and (%) Land and Capital Holders in Total Population.

Table 3.1: Variables

Name	**Source**	**Code**	**Time**	**Mean**	**Sd**
Institutional Quality Indicator	P.B.M. Ministry	IQIM	2000	3.0080	0.4422
Gross Domestic Product *per capita*	IpeaData	GDP^{pc}	2000	341.8538	201.6832
Human Capital *per capita*	IpeaData	H^{pc}	2000	8.6218	9.1076
Latitude	IBGE	Lat	2000	-15.1161	7.8455
Annual Rainfall	IpeaData	Rain	1960-1990	111.6364	33.1042
Demographic Density	Census (IBGE)	DD	1872	11.0965	18.3531
(%) Slaves	Census (IBGE)	Slav	1872	0.1434	0.1003
(%) Immigrants	Census (IBGE)	Immi	1872	0.0053	0.0269
(%) Judges	Census (IBGE)	Jud	1872	$3.61(10^{-8})$	$1.03(10^{-7})$
(%) Military	Census (IBGE)	Milit	1872	0.0014	0.0043
(%) Land and Capital Holders	Census (IBGE)	LandH	1872	0.0031	0.0046

Note: Variables descriptions, database, time periodicity and specification.

In the past, slavery was one of the most remarkable institutions of Brazilian society. Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) indicate that the allocation of slaves, among Brazilian regions, occurred in response to changes in production demand. This change already reflected regional inequalities in the late nineteenth century and persist after its abolition, reflecting the behavior of current institutions.

Prado Jr (1945) indicates that the structures of labor relations in Brazil underwent important transformations. Under pressure from the British authorities, the imperial government incorporated actions that prevented the expansion of slave labor. Thus, by the mid-1850s, the big coffee farms were having difficulties to find enough labor. The Brazilian government tried to overcome this problem by subsidizing the coming of European workers for large coffee farms, mainly through the payment of tickets. According to Menezes-Filho, Marcondes, Pazello and Scorzafave (2006), in regions where the proportion of foreigners was higher, institutions are better today.

Regarding the judiciary, Williamson (1985) develops a theoretical framework that relates the performance of the judicial system with economics: a high-performance economy (expressed in terms of governability) supports more mid-level transactions than will occur in an economy whose judiciary is problematic. The work of Pinheiro and Cabral (1998) was one of the first to empirically relate the quality of the judiciary in the development of the Brazilian credit market. However, in the absence of a qualitative measure, we used the proportion of judges in the total population.

Furthermore, for the percentage of military, Prado Jr (1945) indicates that the empire sought to intensify border patrols through military colonies and to allocate populations to unpopulated districts. Therefore, we consider this percentage to be representative of the de jure power imposed by the empire.

According to Acemoglu,Johnson and Robinson (2002) and Engerman and Sokoloff (2002), demographic density is directly associated with the per capita income level. In the case of the Brazilian regions, 1872, richest areas probably concentrated a large part of the population. Therefore, we use this variable as a proxy for economic prosperity.

Finally, the percentage of land and capital holders may capture income inequality and concentration of political power. This variable, which represents the de facto power, is highlighted by Piketty (2014)and Acemoglu and Robinson (2015). We then expect a negative correlation between these proportions and actual institution quality. Consequently, we believe that a greater concentration of wealth in 1872 can be reflected in a bad development of current institutions.

We believe that these variables can represent the inequality of wealth and political concentration in the units analyzed, throughout Empire of Brazil, reflecting the problems of exploratory colonization. Thus, we use them as possible determinants of current institutions. In addition, as explanatory variables, to control geographic variations (see Nakabashi,Pereira and Sachsida (2013)), we always use: latitude and rainfall between 1960 and 1990 (following Sachs (2003) arguments).

We start with a basic idea that the level of current institutions is directly related to the past institutions (Z^{Proxy}). In the first stage we estimate:

$$IQIM_i = \beta_0 + \beta_1 Z_i^{Proxy} + \beta_2 Lat_i + \beta_3 Rain_i + u_i \tag{3.1}$$

To select the best model, to be used in the first stage, we analyzed the Akaike Information Criterion (AIC), R^2 and weak instrument tests (F, Wu-Hausman and Sargan).

Finally, we estimate the effect of institutions on income, controlling for current human capital (see Rodrik, Subramanian and Trebbi (2004))[7]:

$$GDP_i^{pc} = \theta_0 + \theta_1 \widehat{IQIM}_i + \theta_2 H_i^{pc} + \mu_i \tag{3.2}$$

3.4 Results

First, we present the database correlation-matrix. We note that the IQIM variable seems to be positively correlated with: Slaves, Immigrants, Military and Demographic Density and negatively with: Judges and Land and Capital Holders. In addition, except for Land Holders, all other variables are positively related to per capita GDP:

	GDP	*H*	*IQIM*	*Lat*	*Rain*	*DD*	*Slav*	*Immi*	*Jud*	*Milit*	*LandH*
GDP	1.000	0.458	0.759	−0.779	0.324	0.263	0.304	0.154	0.063	0.141	−0.090
H	0.458	1.000	0.398	−0.279	0.210	0.432	0.173	−0.016	0.0586	0.096	−0.077
IQIM	0.759	0.398	1.000	−0.699	0.265	0.197	0.284	0.173	−0.005	0.139	−0.106
Lat	−0.779	−0.279	−0.699	1.000	−0.261	−0.059	−0.382	−0.228	−0.022	−0.047	0.069
Rain	0.324	0.210	0.264	−0.261	1.000	0.111	0.166	0.111	−0.019	0.146	−0.075
DD	0.263	0.432	0.197	−0.059	0.111	1.000	0.143	−0.025	0.076	0.228	−0.012
Slav	0.304	0.173	0.284	−0.382	0.166	0.143	1.000	−0.035	0.074	−0.020	0.012
Immi	0.155	−0.016	0.173	−0.229	0.112	−0.025	−0.036	1.000	0.018	0.006	−0.066
Jud	0.063	0.059	−0.005	−0.022	−0.020	0.077	0.075	0.018	1.000	0.114	0.121
Milit	0.141	0.096	0.139	−0.047	0.147	0.229	−0.021	0.006	0.114	1.000	0.067
LandH	−0.090	−0.077	−0.106	0.069	−0.075	−0.012	0.012	−0.066	0.121	0.066	1.000

For the first stage, we estimate the effectiveness of each regressor:

Table 3.2: Regressions Results - OLS (First Stage)

Variable	**(1.1)**	**(1.2)**	**(1.3)**	**(1.4)**	**(1.5)**	**(1.6)**	**(1.7)**
Intercept	2.297*	2.302*	2.304*	2.307*	2.287*	2.323*	2.319*
Latit	−0.037*	−0.038*	−0.038*	−0.038*	−0.037*	−0.037*	−0.037*
Rain	0.001**	0.001**	0.001**	0.001*	0.001*	0.001*	0.001*
Slaves	0.060						
Immig		0.156					
Judges			−47.988				
Milit				9.795*			7.318*
D.Density					0.003*		0.003*
LandHold						−5.043**	−5.550**

Note: OLS estimations (Stage 1).(∗) is relative to 1%, (∗∗) 5% and (∗ ∗ ∗) 10%.

[7]Methodologically, IPEA calculate the stock of human capital by the difference between the income obtained in the labor market and the estimate of that obtained by a worker without education and experience. To estimate expected future earnings, the institute uses the coefficients of return to education and experience estimated by the Demographic Census data (for 1980, 1991 and 2000) and PNAD (in the other years 1981-99).

The signs of the coefficients follow what was indicated by the correlation matrix. However, Table 3.2 provides additional evidence as to the significance of these relationships. As expected and suggested by Nakabashi,Pereira and Sachsida (2013), Latitude and Rain are always significant with almost no variations in coefficients between the estimated models.

As for the demographic census variables of 1872, the percentages of slaves, immigrants and judges were not statistically significant. The signs for the first two variables are the same as those found by Menezes-Filho, Marcondes, Pazello and Scorzafave (2006). However, in this paper, the number of immigrants was not significant, which goes against the evidence presented by Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) using 1920 data.

For the other variables (Military, Demographic Density and Land Holders) we found statistical significance. The results indicate that a higher percentage of military (presence of de jure power) is associated with better institutions and higher demographic density in 1872 is associated with better current institutional quality in 2000 (as opposed to the reversal of fortune hypothesis, Acemoglu,Johnson and Robinson (2002)). Finally, for Land Holders proxy, we expect that a higher concentration of de facto power in 1872 will be related to the worsening of current institutions.

We use the HAC matrix for estimate robust standard errors. Moreover, to select the best model we look to significance, the usual Akaike Information Criterion (AIC) and R^2:

Table 3.3: OLS (First Stage)

	(1.1)	**(1.2)**	**(1.3)**	**(1.4)**	**(1.5)**	**(1.6)**	**(1.7)**
AIC	257.009	257.072	256.972	248.489	235.728	254.475	232.876
R^2	0.493	0.489	0.488	0.502	0.515	0.496	0.523

Note: Akaike Information Criterion and Goodness of Fit.

Table 3.4: Weak Instruments Tests

Test	**(1.4)**		**(1.5)**		**(1.6)**		**(1.7)**	
	Stat.	**p-value**	**Stat.**	**p-value**	**Stat.**	**p-value**	**Stat.**	**p-value**
F-Weak	166.090	0.000	179.501	0.000	175.885	0.000	160.090	0.000
Wu-Hausman	153.240	0.000	218.612	0.000	186.564	0.000	150.452	0.000
Sargan	1.058	0.597	2.015	0.365	1.573	0.455	1.801	0.608

Note: Instruments tests, with respective statistics and p-values.

As we can see, model (1.7), presents the lowest AIC's. Furthermore, model (1.7) provides $R^2 = 0.523$. But before following to the second stage we execute an F test of the first stage regression for weak instruments, a Wu-Hausman test and a Sargan test of over identifying restrictions:

The test results, for all specifications, indicate that: i) In the F-Weak of joint significance, we reject the null hypothesis that the instruments are weakly correlated with the endogenous variable; ii) For the Wu-Hausman test, we reject the null hypothesis that the OLS and IV estimates are equally consistent; and iii) For the Sargan test, we do not reject the null hypothesis that all instruments are in fact exogenous and not correlated with model residuals.Then, after the analysis of the information criterion and testing weak instruments, we move on to the second stage using (1.7) as the first stage[8].

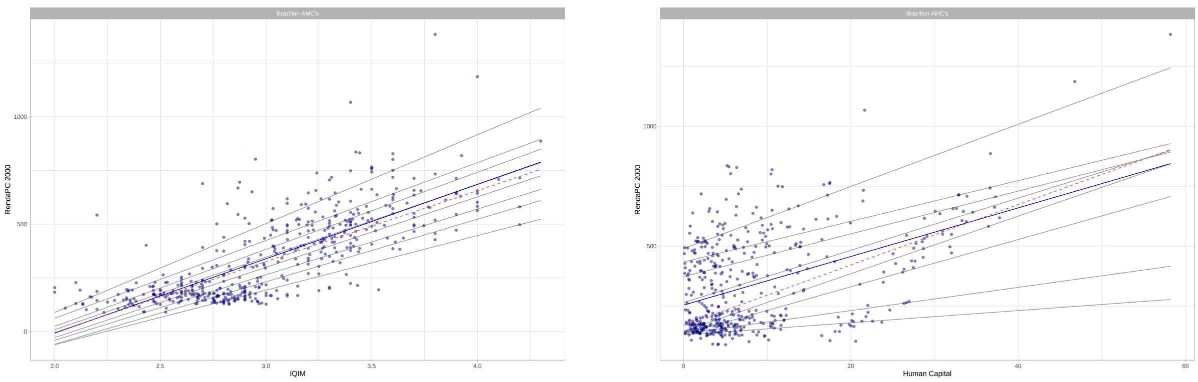
In a country with such a large geographical extension as Brazil, regional characteristics may easily influence GDP patterns. Thus, the quantile analysis seems to be a suitable method. To reinforce the use of QR, we performed the Breusch-Pagan test:

Table 3.5: Heteroscedasticit Test

	Statistic	**p-value**	**Method**
$Breusch - Pagan$	46.901	0.000	Studentized

Note: Breusch-Pagan test, studentized, to detect heteroscedasticity.H_0: There is no heteroscedasticity.

Figure 3.1: Stage: 2

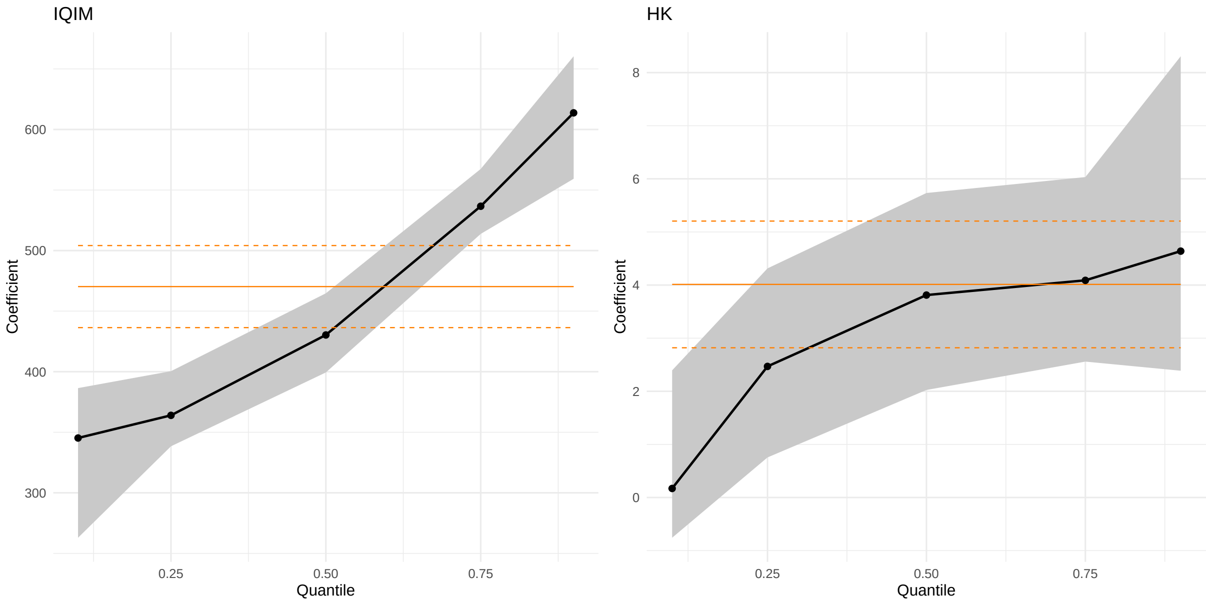


Note: Simple QR estimations.

[8]A small loop selection algorithm was developed to choose the best model, the results indicate model (1.7) out of all possible combinations.

The test indicates that we can reject the null hypothesis of homoscedasticity in the data. Furthermore, we present the simple (bivariate) quantile regressions between explanatory variables: IQIM and Human Capital, on GDP per capita. We consider the quantiles $\tau = \{0.10, 0.20, ...0.90\}$. The blue line represents the OLS estimation, the red line the QR estimation in the 0.50 quantile and the gray lines represent the other estimated quantiles.

Figure 3.2: Coefficients



Note: Estimated coefficients: QR and 2SLS.

Simple quantile results show that the marginal effects of institutions and human capital on per capita income may oscillate at various quantiles of the conditional distribution. Following, using the first stage fitted values, estimated by an OLS regression [9], we proceed to the multiple regression in the second stage.

The results of the second stage show that institutional quality has a positive and significant effect on the per capita income of comparable minimum areas, with R^2 of approximately 70%. Moreover, as we can see from quantile estimates, the effects areasymmetric since steeper slopes are observed at higher percentiles. As a result the gap between income per capita increases with institution quality, being a major source of the heteroscedasticity initially indicated by the Breusch-Pagan test. Similar pattern is not observed for the marginal impacts of human capital, since the coefficients over quantiles are more similar and situated inside the confidence interval of OLS estimate (figure 3.2). The only real dif-

[9] Additionally, in the Appendix, the quantile estimates for the first stage are also presented.

ference is observed at extreme low quantiles, where coefficients a are not significant. This indicates that human capital is not a factor influencing the very low levels of conditional GDP per capita Institutions, on the other hand,impacts positively even the lowest levels of income per capita. Furthermore, the partial R^2 also shows the preponderance of our instrumentalized institution variable: 60% against 20% of the human capital. They are both important, but the influence of institution is much higher.

Looking deeper into the Institutions versus Human Capital debate (see Glaeser, La Porta, Lopez-de-Silanes and Shleifer (2004)), we calculate the elasticity of IQIM and Human Capital per capita series to estimate which of the variables has the greatest effect on per capita income. An increase in IQIM has a greater effect than an increase in human capital. This result is valid for both proxies and reinforces what can be observed by analyzing the partial R^2.

Thus, looking the coefficients, we can expect that an increase of 1 point in the Institutional Quality Index (approximately three standard deviations in the fitted values) will be accompanied by an increase between R\$345 and R\$615 in AMC per capita income. Our results are a little different to those found by Nakabashi,Pereira and Sachsida (2013), in lesser magnitude and for comparable minimum areas. We believe that such a difference occurs because of the distinct instrumentalization process, in which we include alternative regressors, and the aggregation in AMC's.

Table 3.6: Regressions Results - Second Stage: 2SLS and 2SQR

Variable	2SLS	**Quantile**	**(2.1)**
		0.10	345.269*
		0.25	363.978*
$IQIM$	463.398*	**0.50**	430.339*
		0.75	536.610*
		0.90	613.725*
		0.10	0.173
		0.25	2.467*
HK^{pc}	5.131*	**0.50**	3.811*
		0.75	4.089*
		0.90	4.639*

Note: QR estimations (Stage 2).

However, even using the 1872 Census for Brazil, it is difficult to make definitive statements about the isolated importance of human capital versus institutions. This difficulty is common in the literature, as highlighted by the disagreement between the works of Acemoglu,Johnson and Robinson (2001) and Glaeser, La Porta, Lopez-de-Silanes and Shleifer (2004).

3.5 Conclusion

The objective of this essay was to measure the relationship between institutional quality and GDP per capita in Brazilian municipalities, using 1872 demographic census to control disparities and the approach proposed by Menezes-Filho, Marcondes, Pazello and Scorzafave (2006) and Nakabashi,Pereira and Sachsida (2013). The difference of our study is that besides using a larger number of variables, from the 1872 census, we focus on the Comparable Minimal Areas (AMC).

The percentage of slaves is used as a measure of past institutions, since it represents the wealth inequality and political power(which sustained for decades, even after its abolition). However, we adopted slightly different empirical strategy and we test different proxies for wealth and political differences in 1872: (%) of Immigrants, (%) of Judges, (%) of Military, Demographic Density and (%) Land and Capital Holders. In addition, as explanatory variables, to control geographic variations, we use: Latitude and Rainfall between 1960 and 1990. Finally, we estimate the effect of institutions on income in the various regions, controlling for human capital.

In the first stage, the coefficients for slaves and immigrants and the statistical significance of slaves are in agreement with the results found by Menezes-Filho, Marcondes, Pazello and Scorzafave (2006). However we find new evidence that the percentage of immigrants and judges were not statistically significant. For Military, Demographic Density and Land Holders we found statistical significance. Our results indicate that a higher presence of de jure power and higher demographic density in 1872 are positively associated with better institutional quality in 2000. Moreover, for Land Holders, the higher concentration of de facto power in 1872 will be related to the worsening of current institutions.

In the second stage, both institutions and human capital are important and positively impact income. However, human capital does not appear to be significant in explaining lower conditioned percentiles of per capita income; On the other hand, institutions impact the entire conditional distribution asymmetrically, resulting in widening differences in per capita income as institutional quality improves. Finally, an increase of 1 point in the Institutional Quality Index will be followed by an increase between $R\$345$ and $R\$615$ in the AMC's per capita income. The results also indicate that changes in IQIM tend to affect AMC's per capita income more than changes in human capital.

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Appendix A

Essay 1

Figure A.1: Alternatives Normalized Ambiguity Proxies

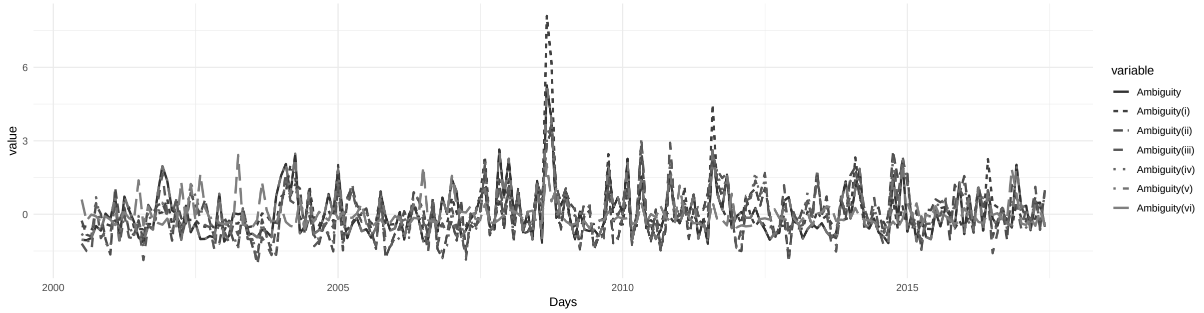


Figure A.2: Impulse Response Functions - VAR - Industrial Production

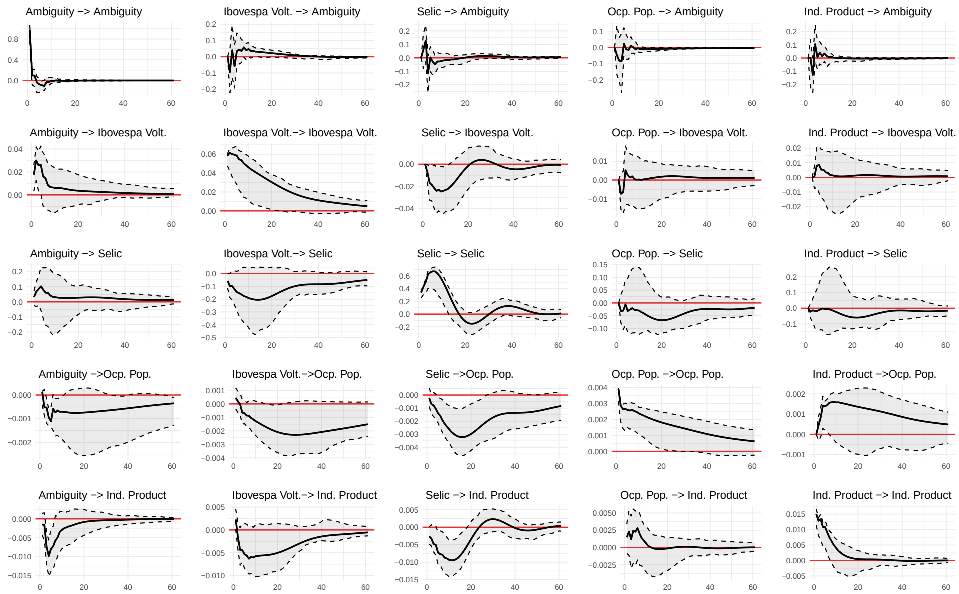


Figure A.3: Impulse Response Functions - SVAR - Industrial Production

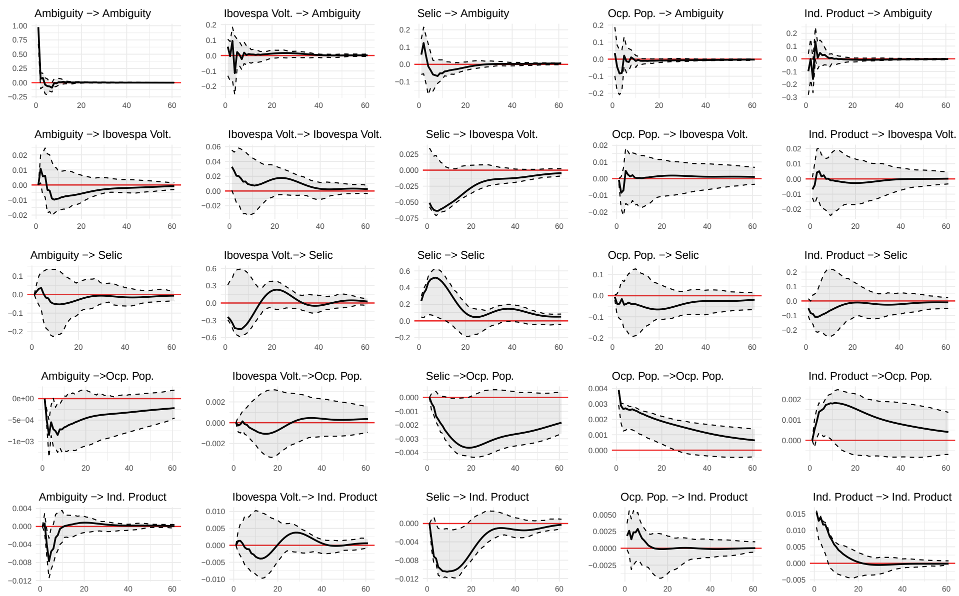


Figure A.4: Impulse Response Functions - VAR - IBC-Br

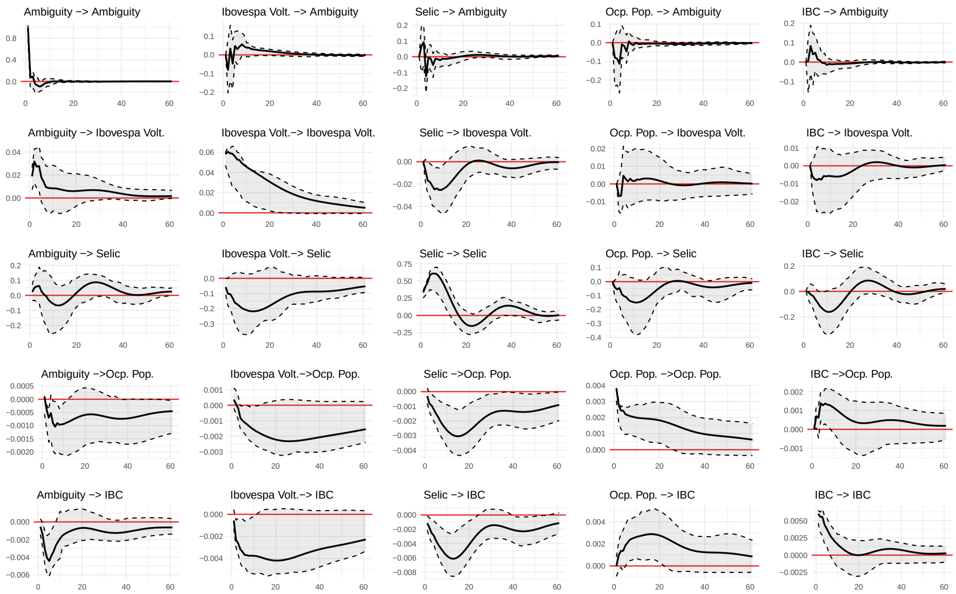


Figure A.5: Impulse Response Functions - SVAR - IBC-Br

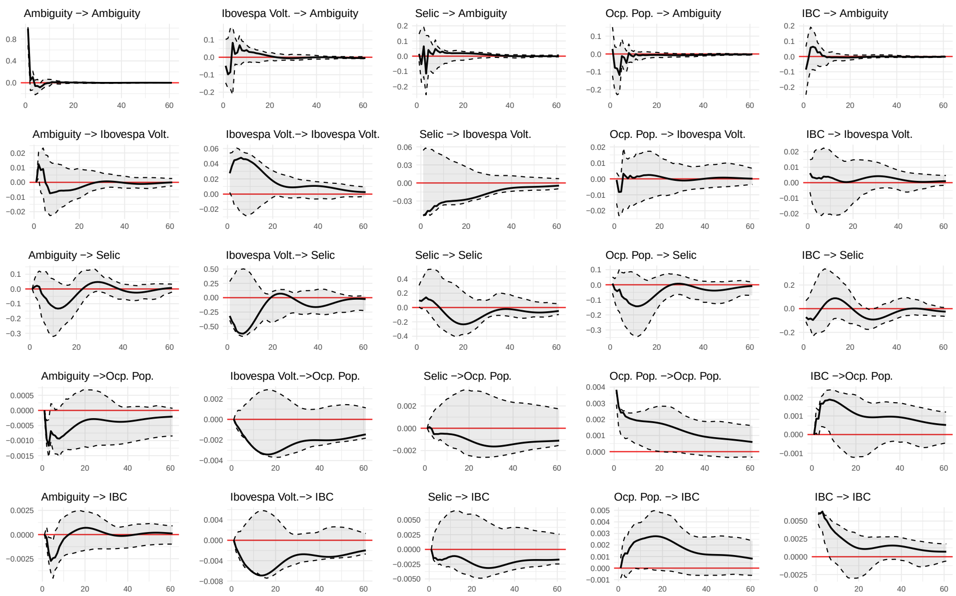


Figure A.6: Impulse Response Functions (i) - VAR - Industrial Production

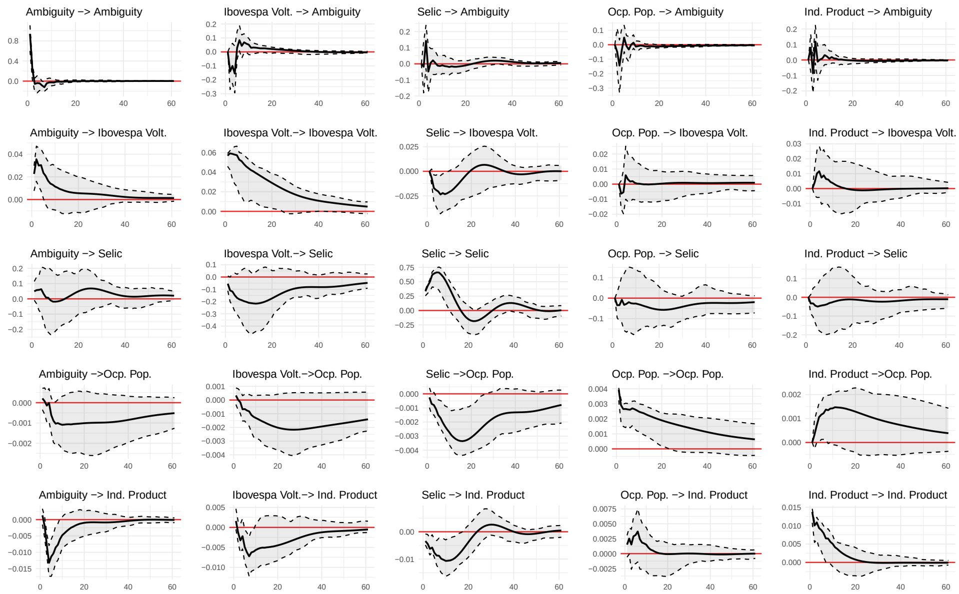


Figure A.7: Impulse Response Functions (i) - SVAR - Industrial Production

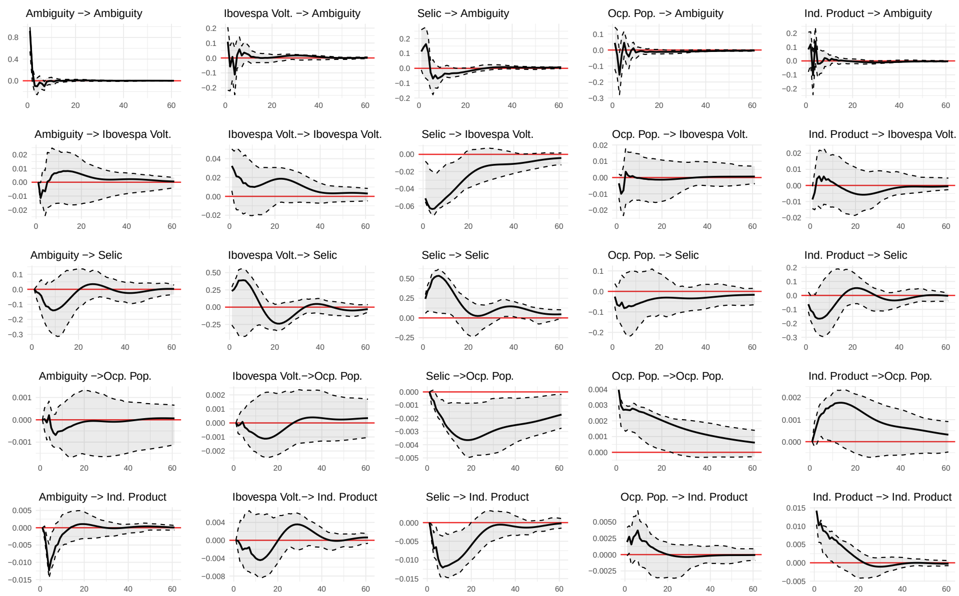


Figure A.8: Impulse Response Functions (ii) - VAR - Industrial Production

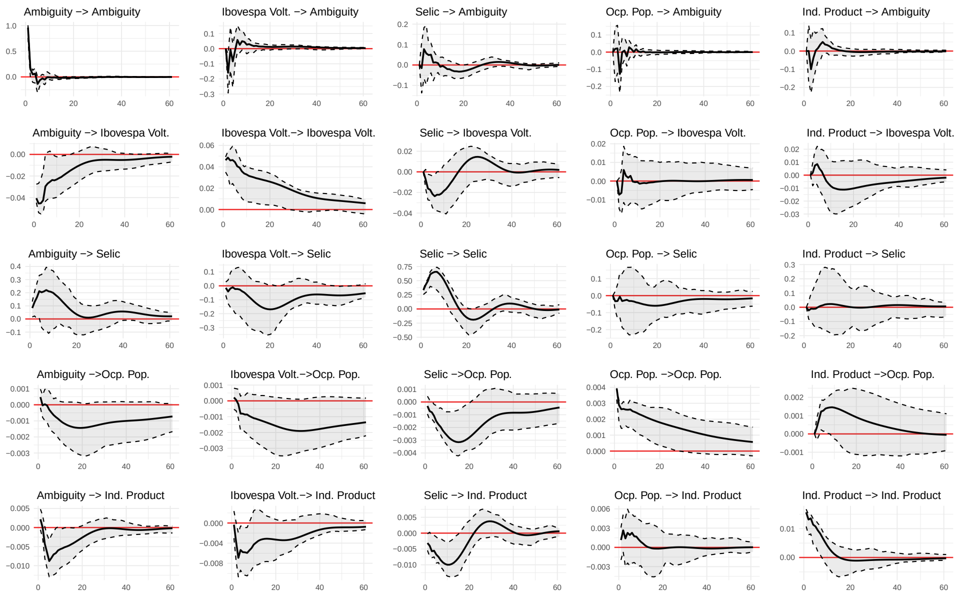


Figure A.9: Impulse Response Functions (ii) - SVAR - Industrial Production

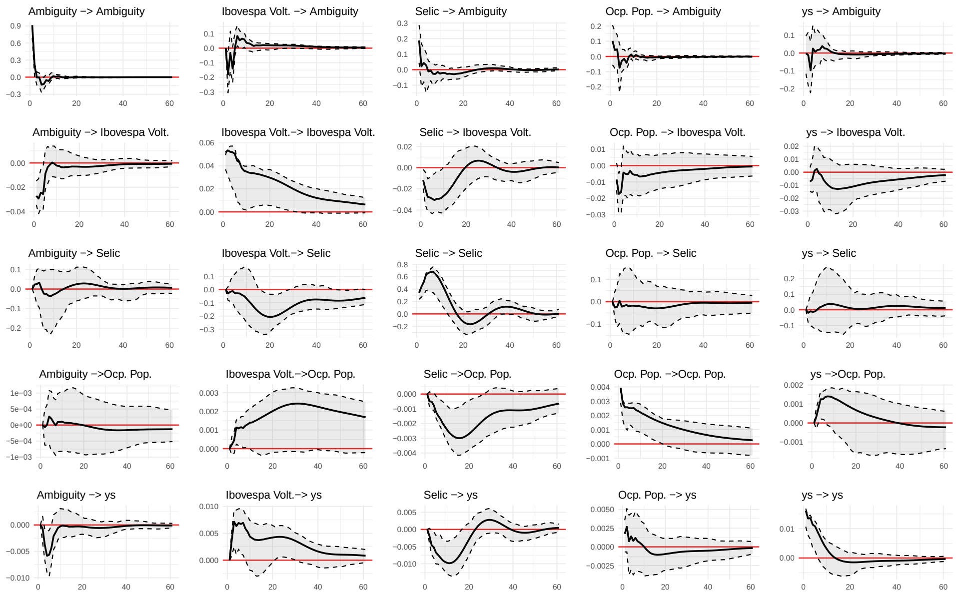


Figure A.10: Impulse Response Functions (iii) - VAR - Industrial Production

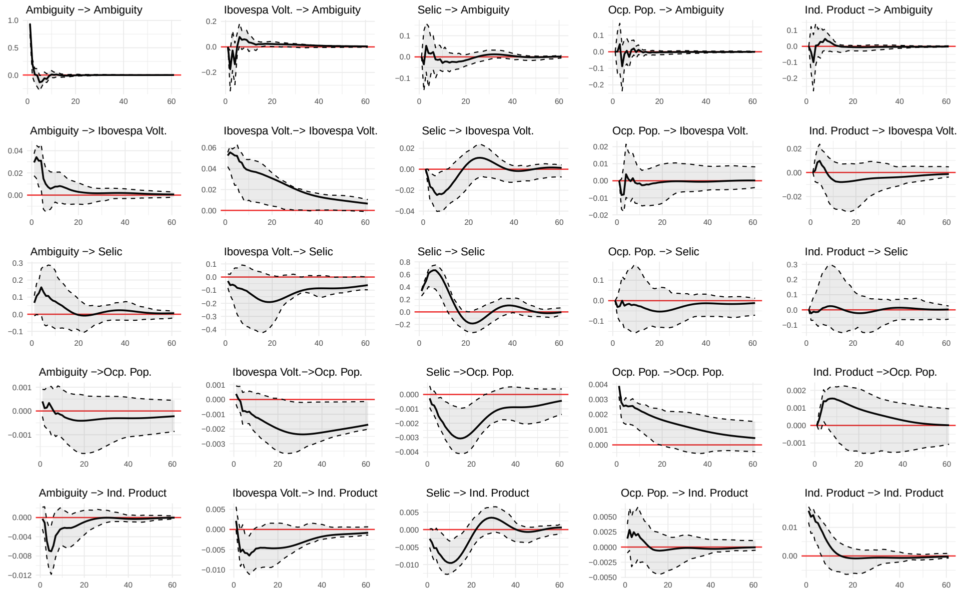


Figure A.11: Impulse Response Functions (iii) - SVAR - Industrial Production

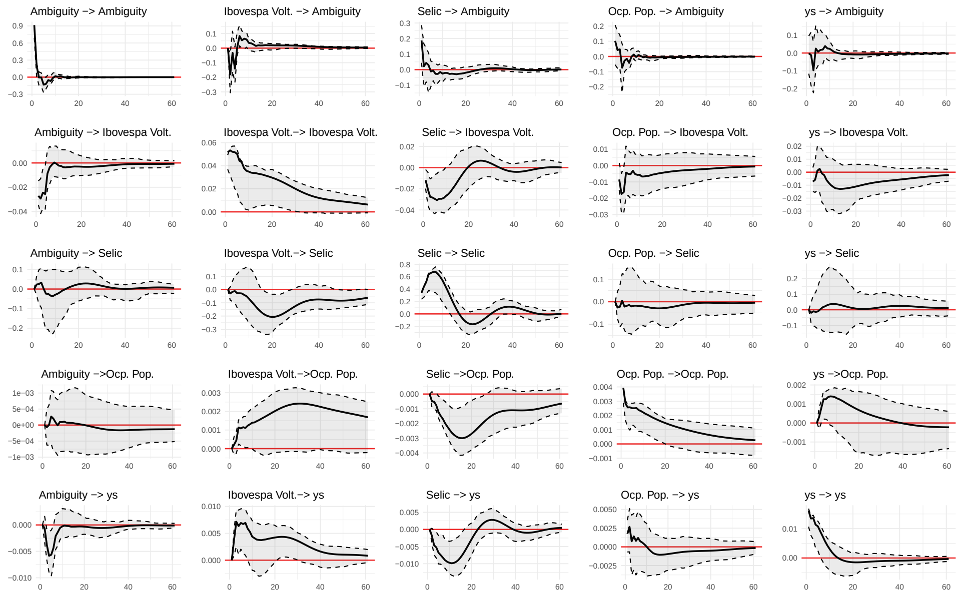


Figure A.12: Impulse Response Functions (iv) - VAR - Industrial Production

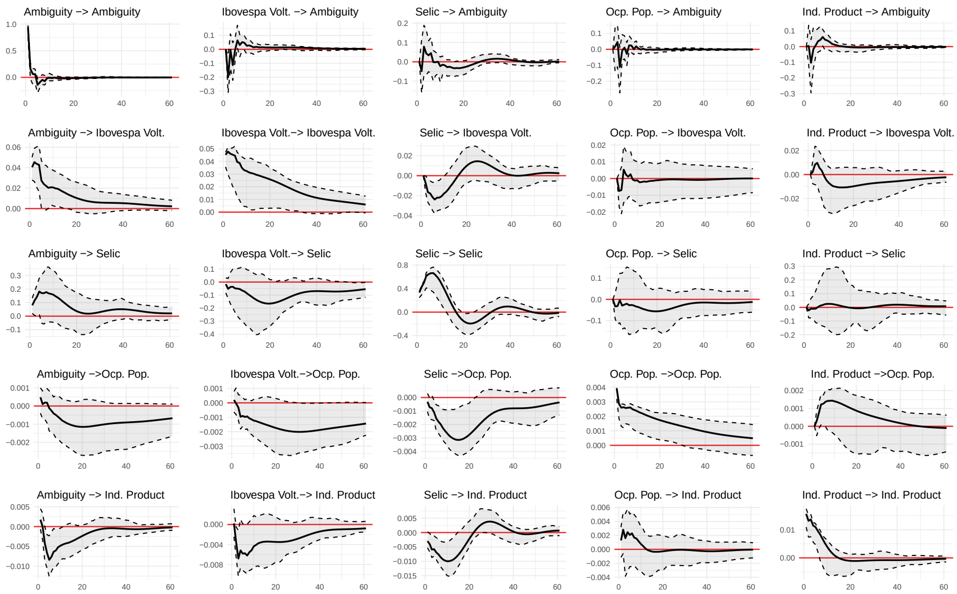


Figure A.13: Impulse Response Functions (iv) - SVAR - Industrial Production

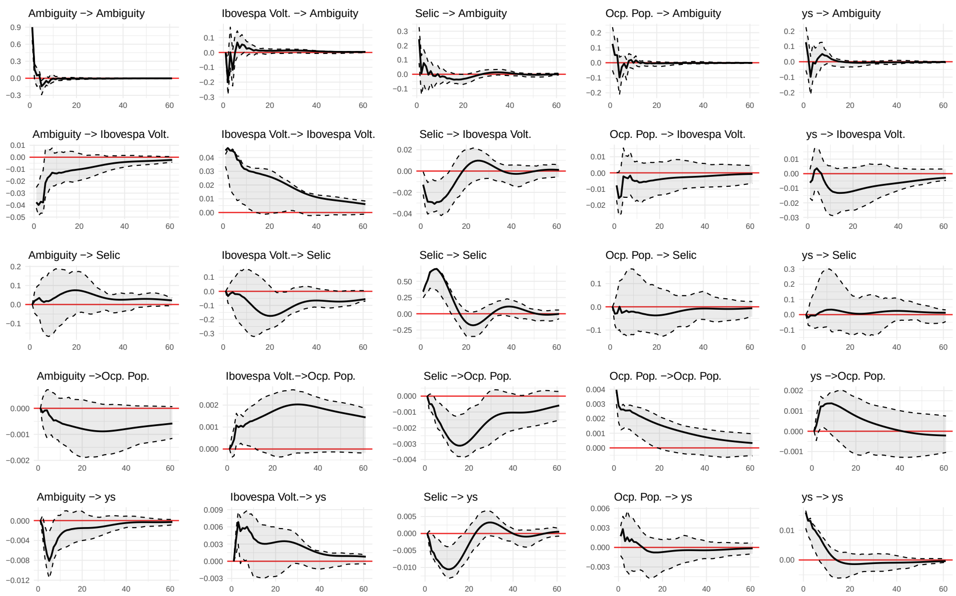


Figure A.14: Impulse Response Functions (v) - VAR - Industrial Production

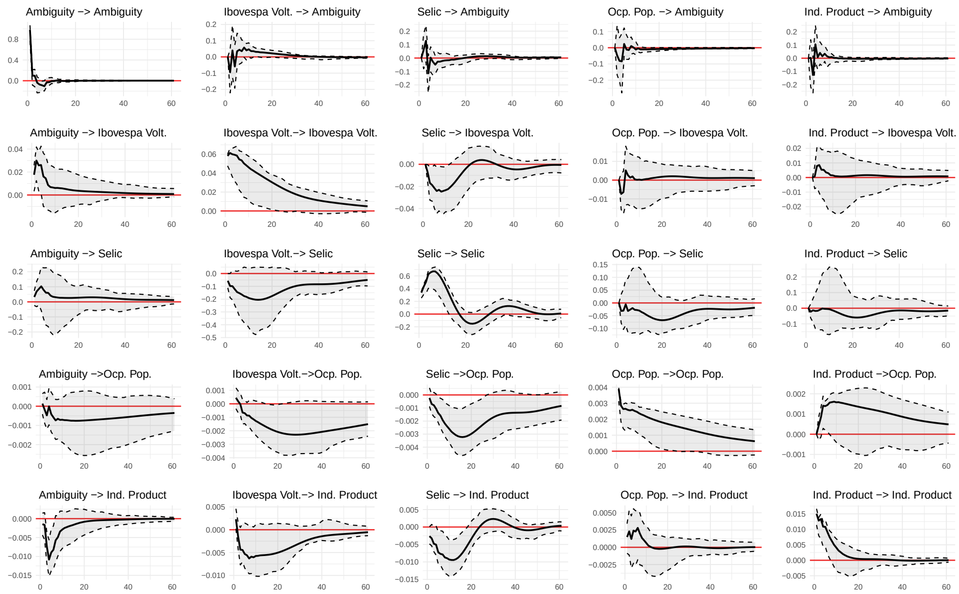


Figure A.15: Impulse Response Functions (v) - SVAR - Industrial Production

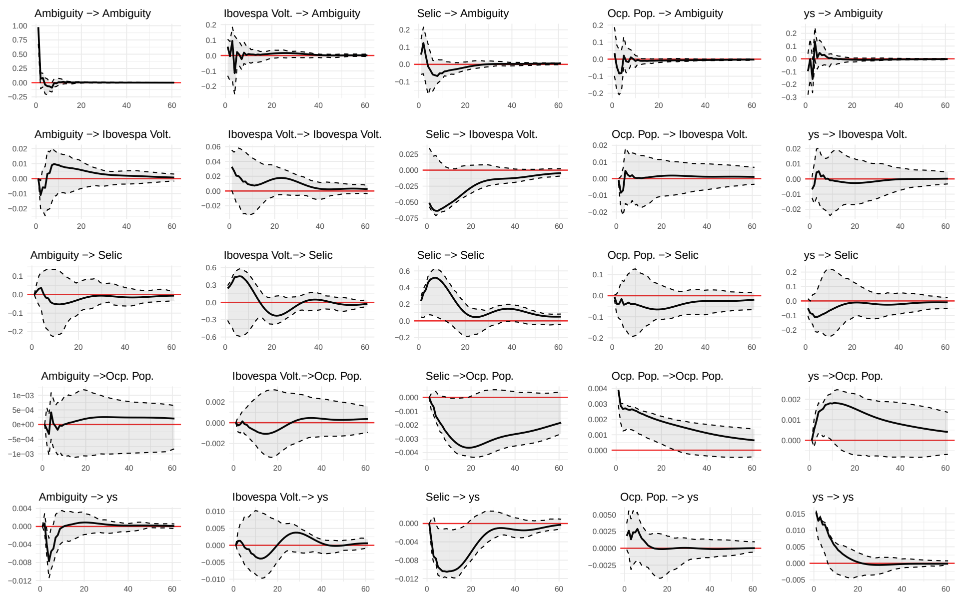


Figure A.16: Impulse Response Functions (vi) - VAR - Industrial Production

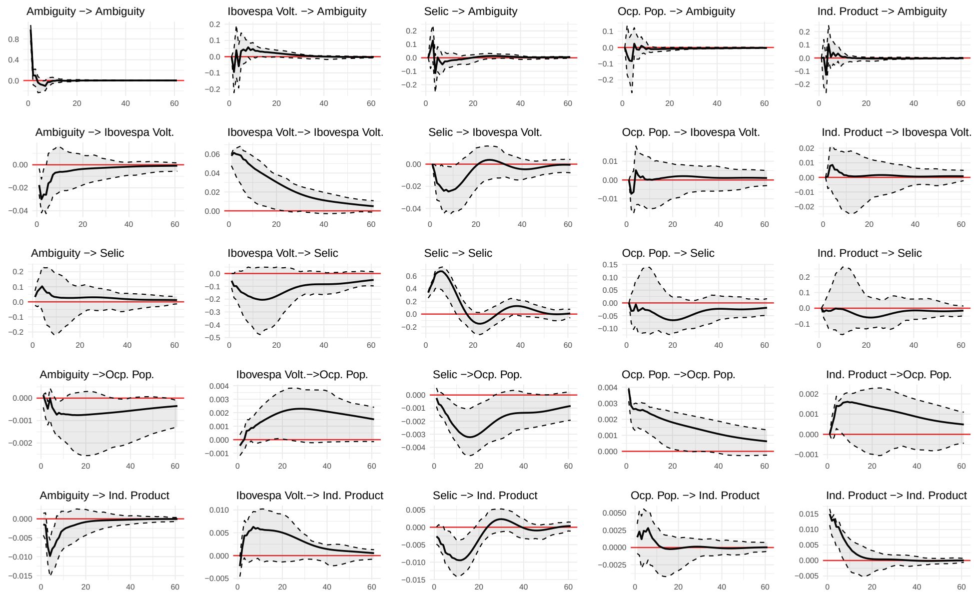


Figure A.17: Impulse Response Functions (vi) - SVAR - Industrial Production

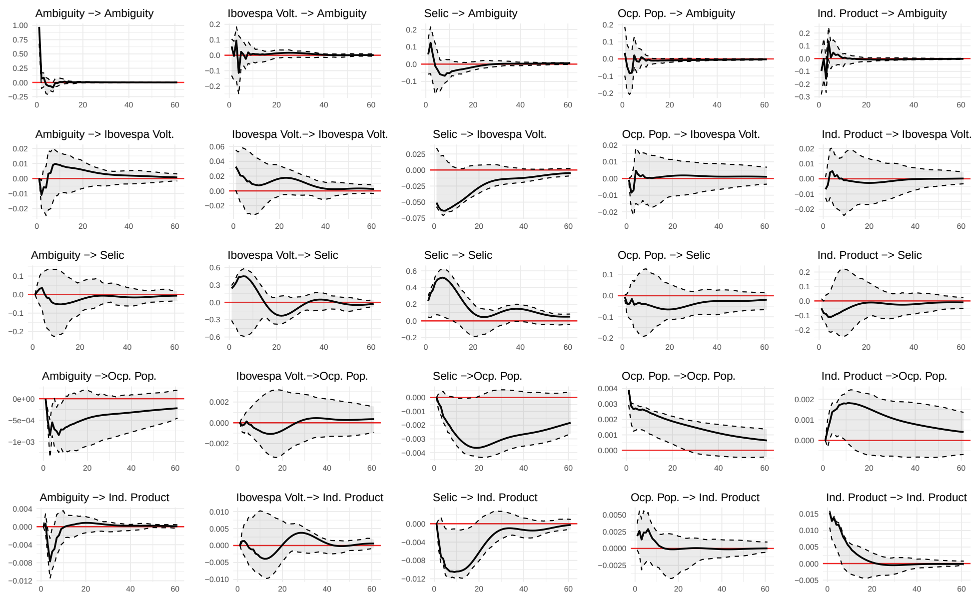


Figure A.18: Impulse Response Functions (a) - VAR - Industrial Production

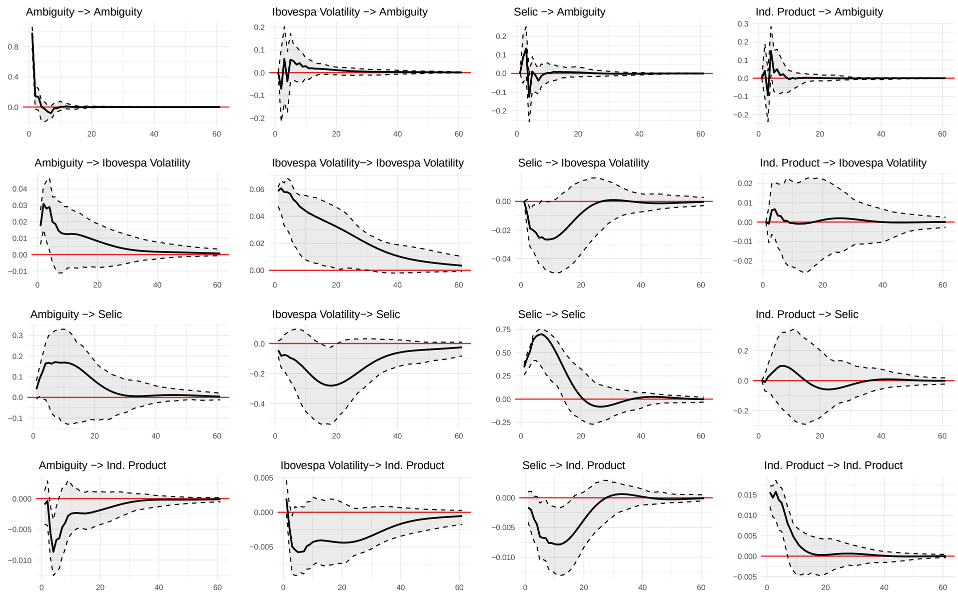


Figure A.19: Impulse Response Functions (a) - SVAR - Industrial Production

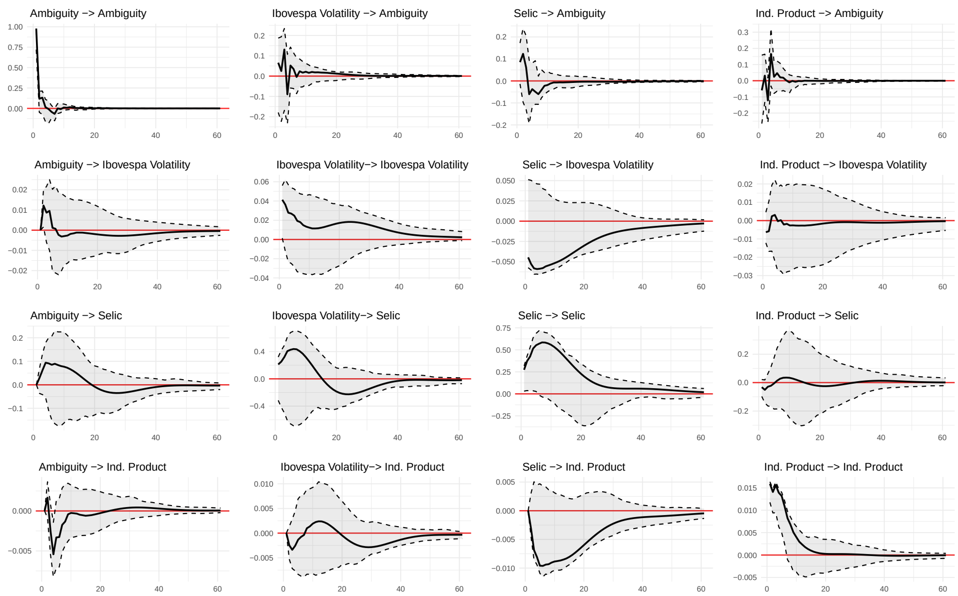


Figure A.20: Impulse Response Functions (b) - VAR - Industrial Production

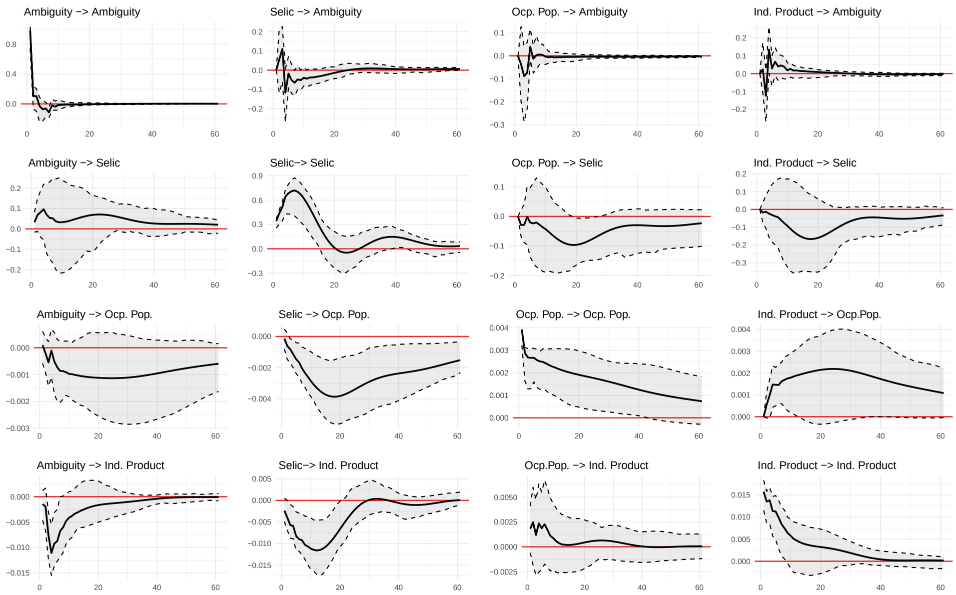


Figure A.21: Impulse Response Functions (b) - SVAR - Industrial Production

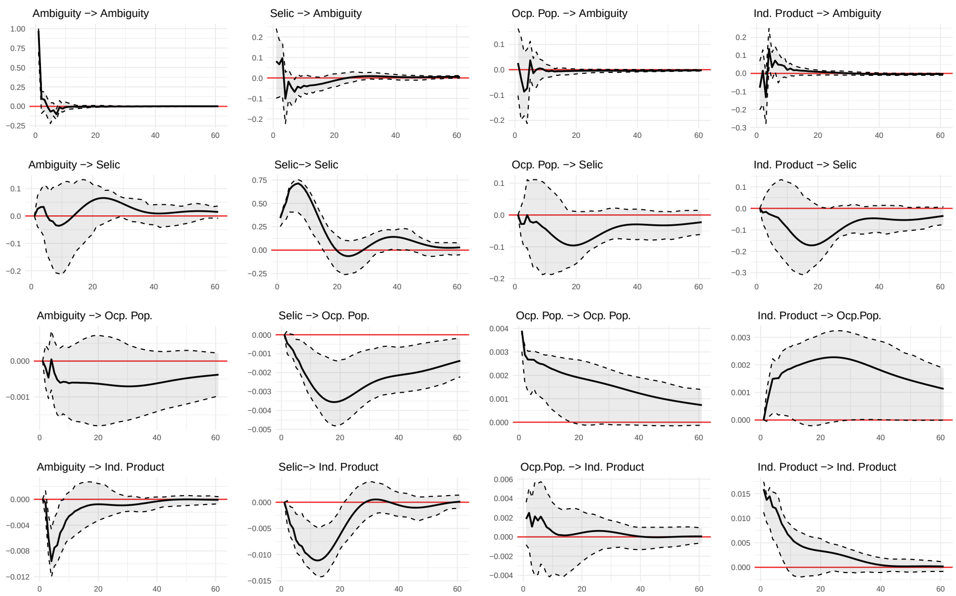


Figure A.22: Impulse Response Functions (c) - VAR - Industrial Production

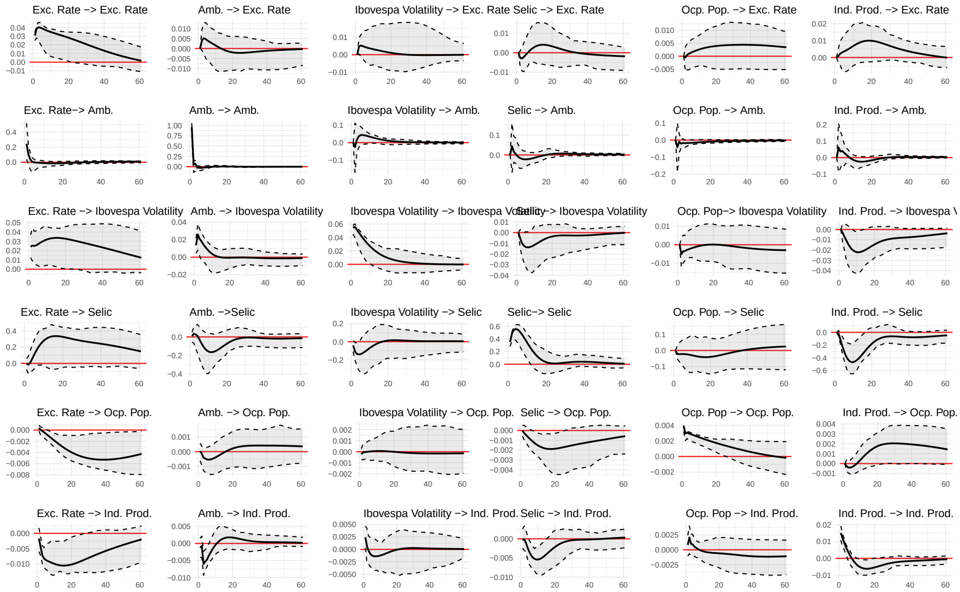


Figure A.23: Impulse Response Functions (c) - SVAR - Industrial Production

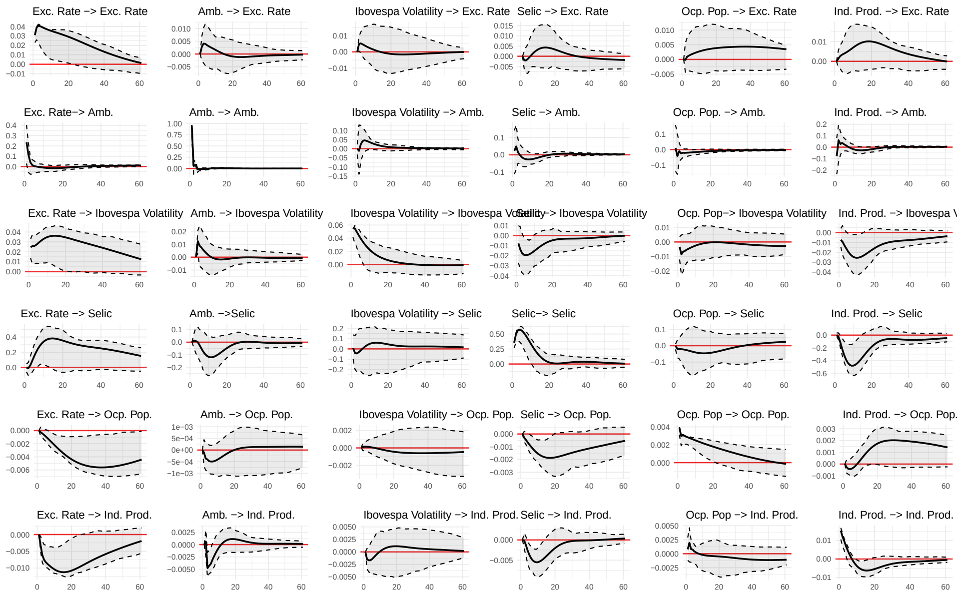


Figure A.24: Impulse Response Functions (d) - VAR - Industrial Production

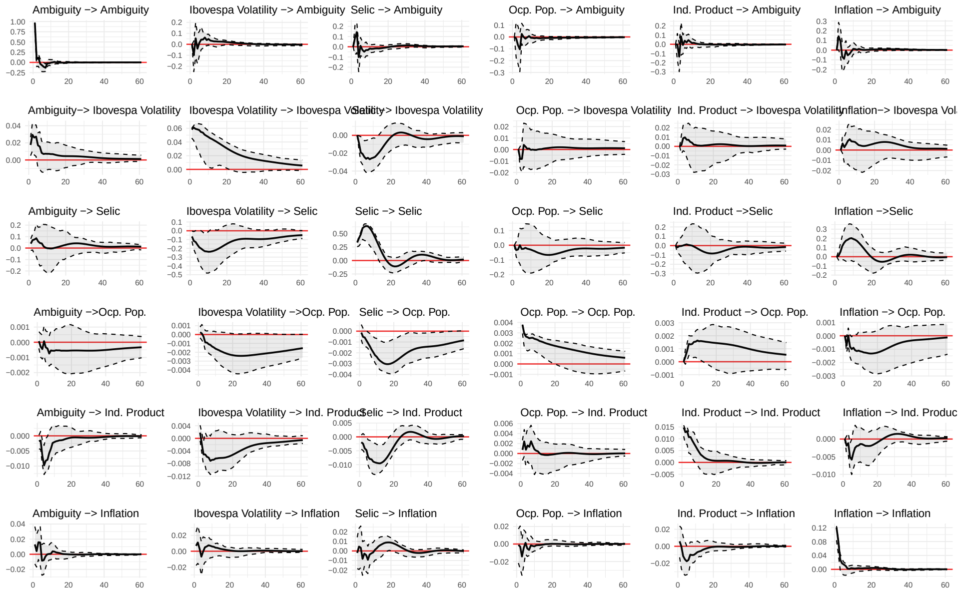


Figure A.25: Impulse Response Functions (d) - SVAR - Industrial Production

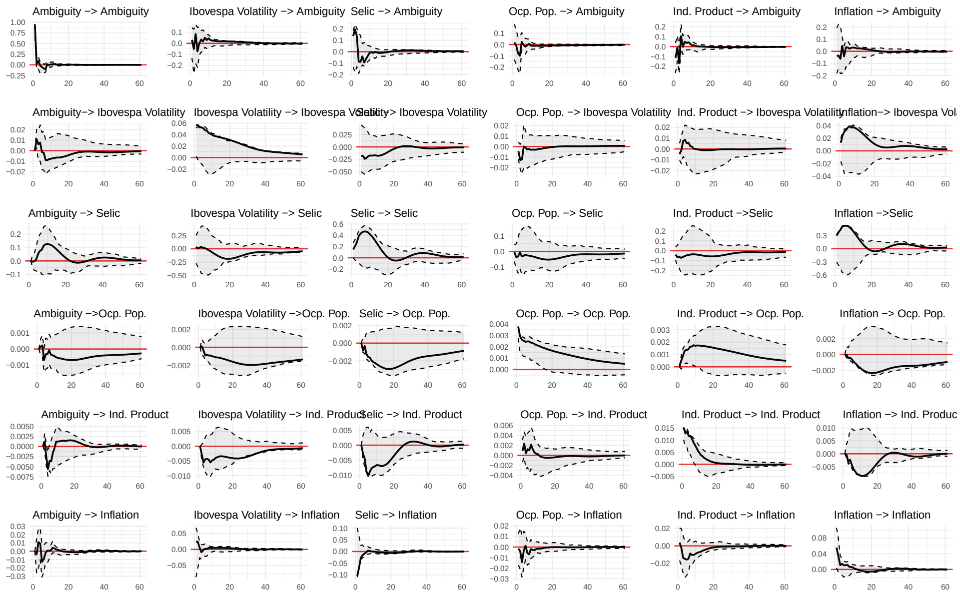


Figure A.26: Impulse Response Functions (e) - VAR - Industrial Production

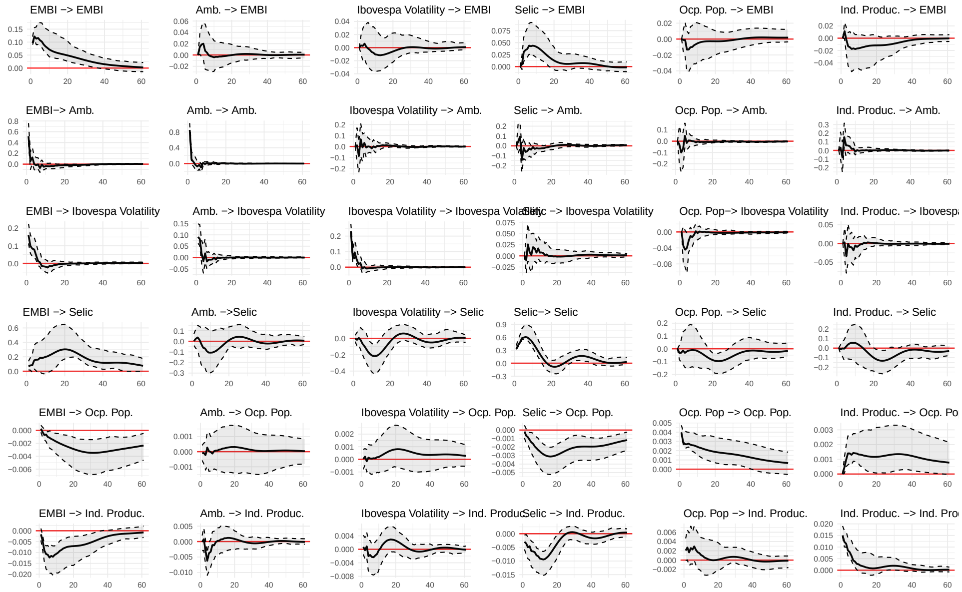


Figure A.27: Impulse Response Functions (e) - SVAR - Industrial Production

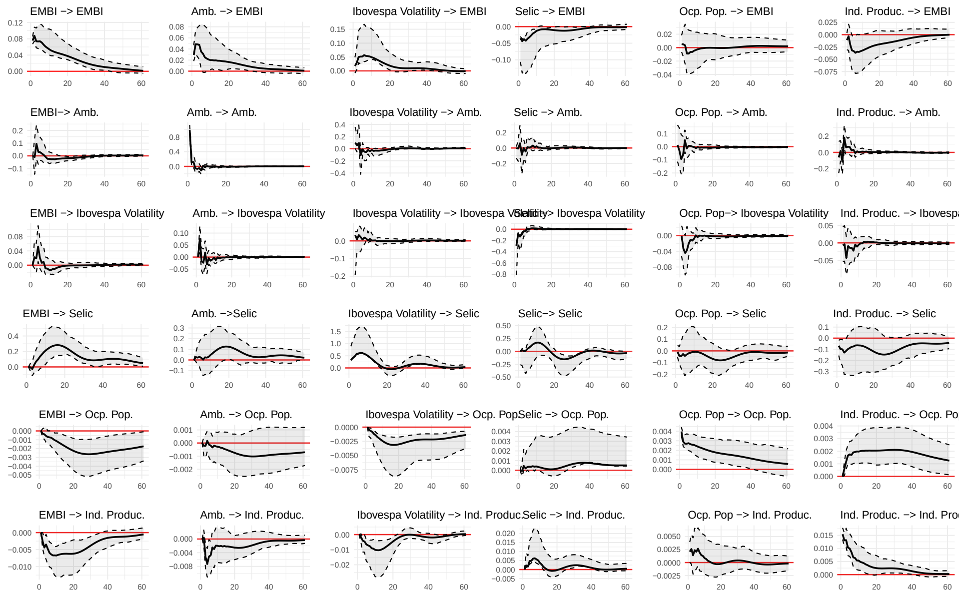


Figure A.28: Impulse Response Functions (f) - VAR - Industrial Production

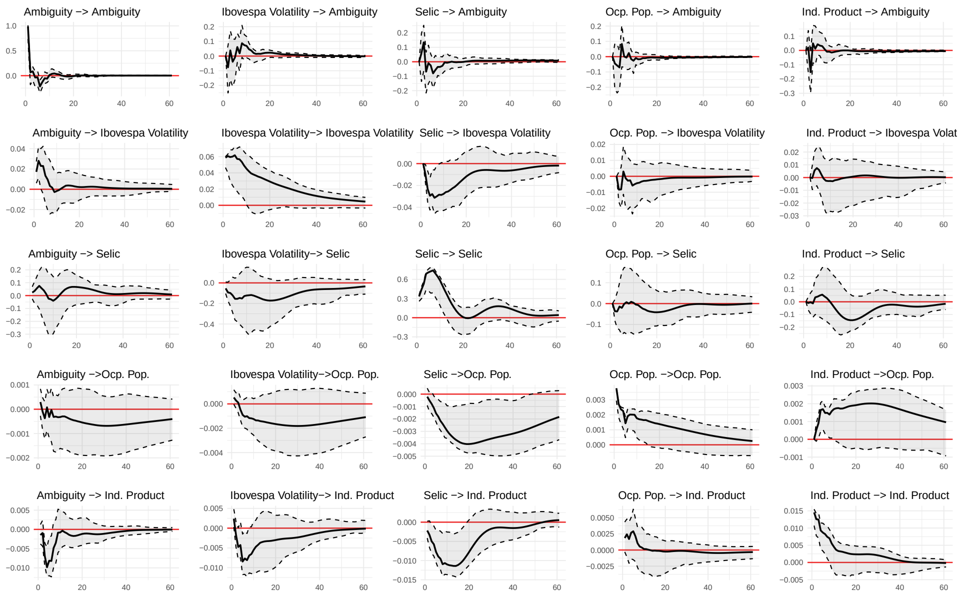


Figure A.29: Impulse Response Functions (f) - SVAR - Industrial Production

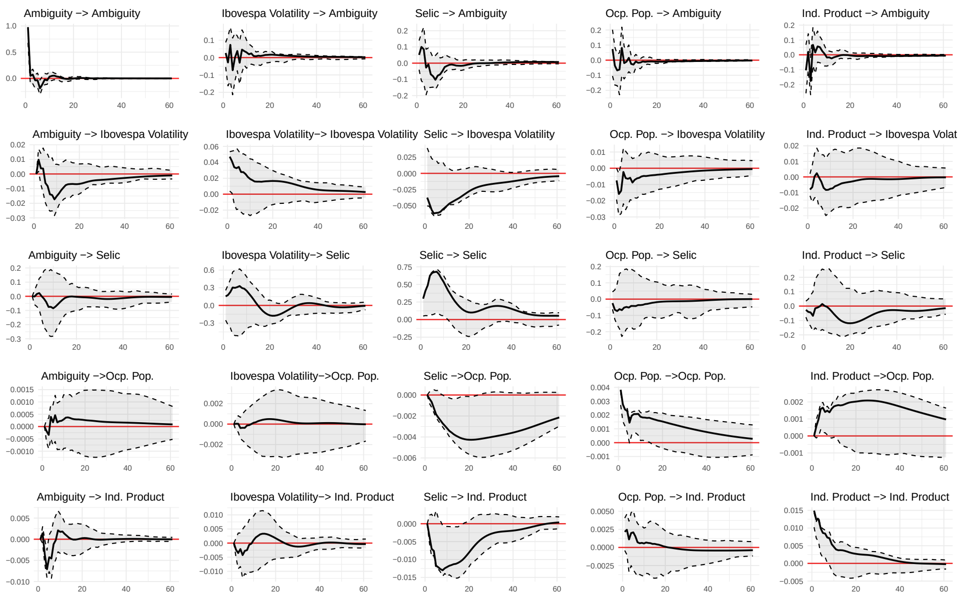


Figure A.30: Impulse Response Functions (g) - VAR - Industrial Production

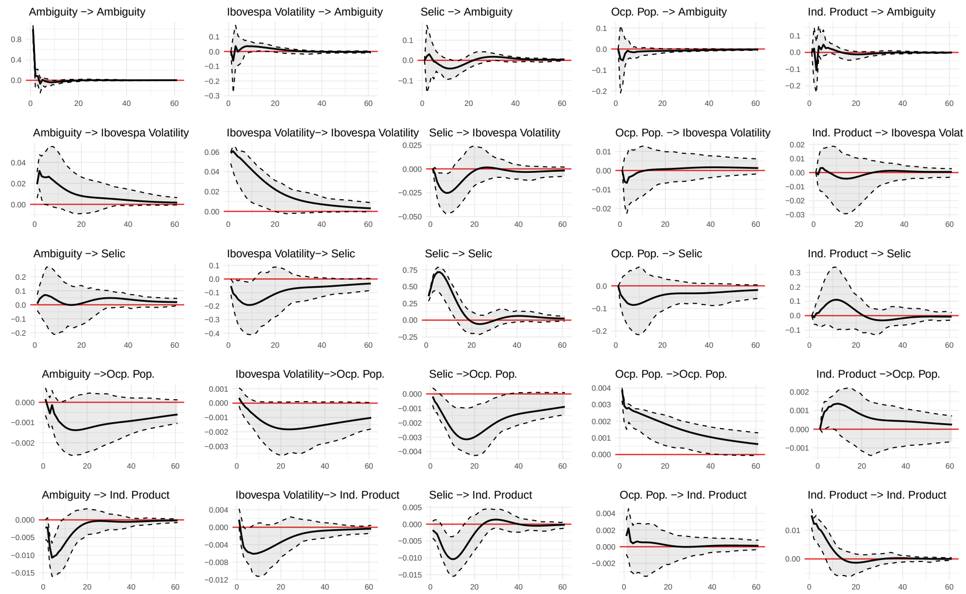


Figure A.31: Impulse Response Functions (g) - SVAR - Industrial Production

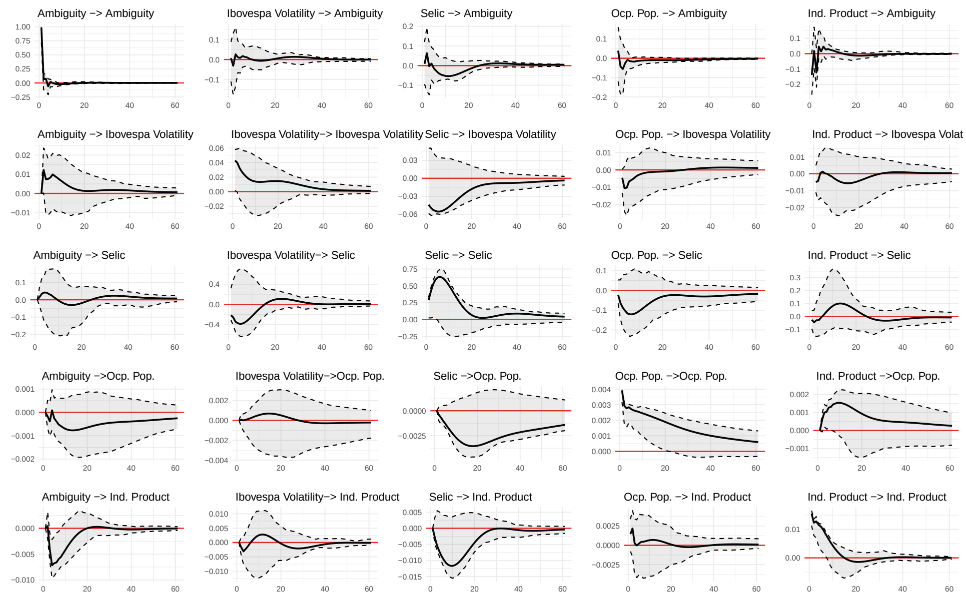


Figure A.32: Impulse Response Functions (h) - VAR - Industrial Production

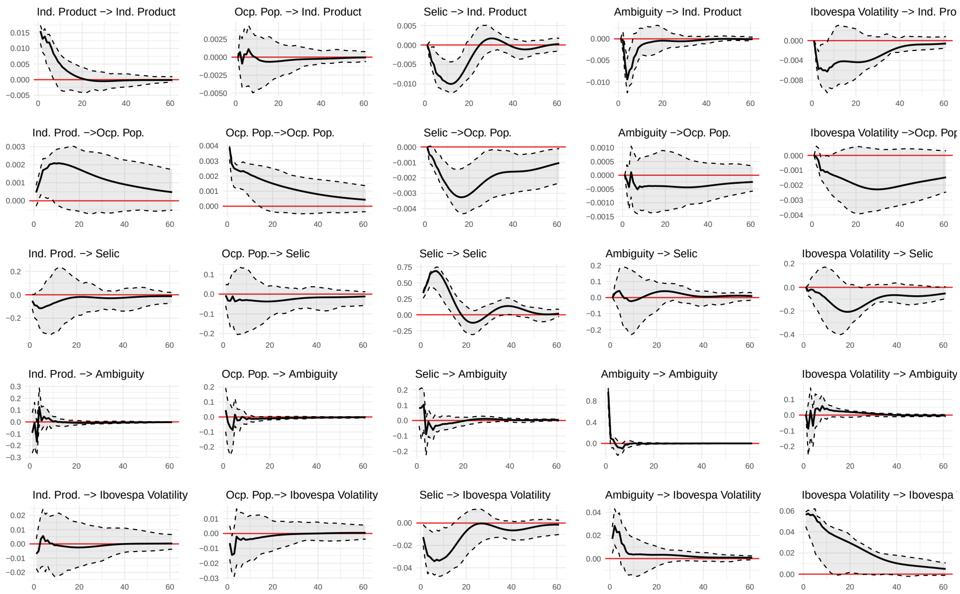


Figure A.33: Impulse Response Functions (h) - SVAR - Industrial Production

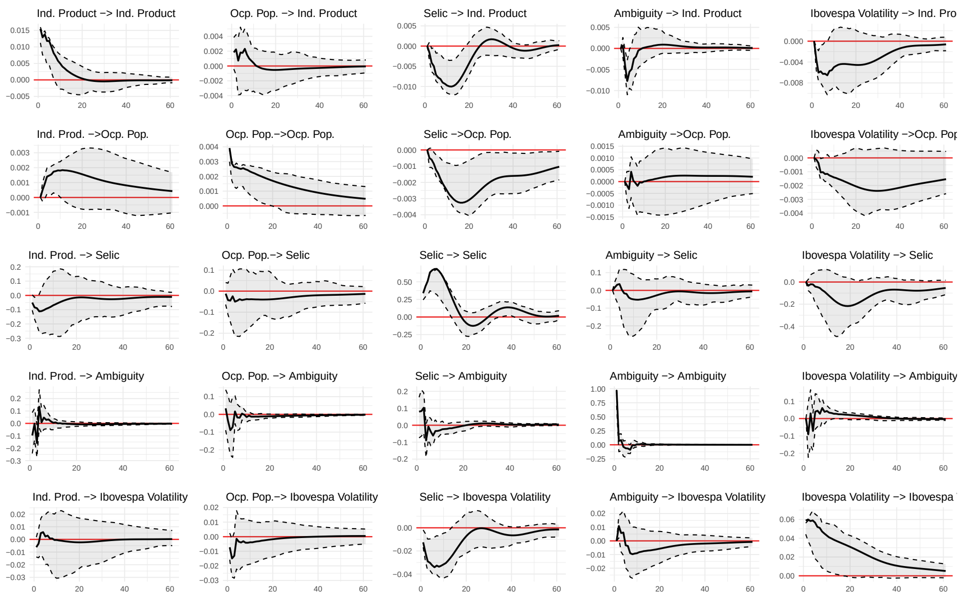


Figure A.34: Impulse Response Functions (i) - VAR - Industrial Production

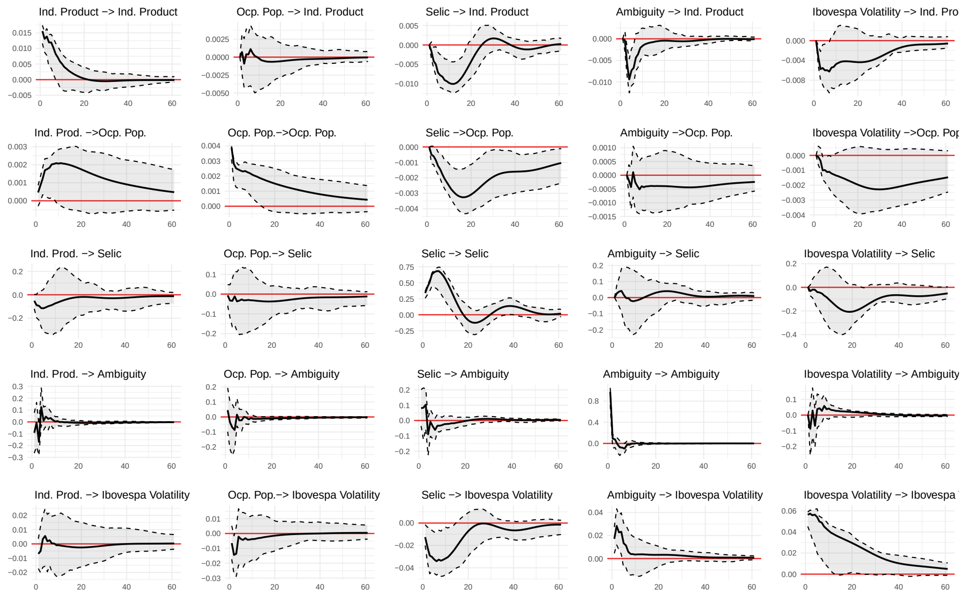


Figure A.35: Impulse Response Functions (i) - SVAR - Industrial Production

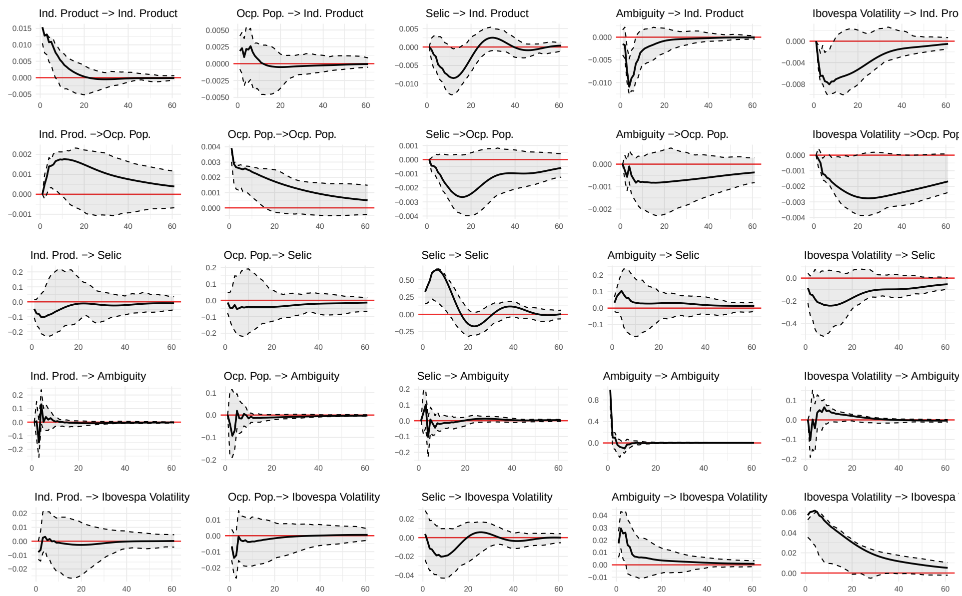


Figure A.36: Impulse Response Functions (k) - VAR - Industrial Production

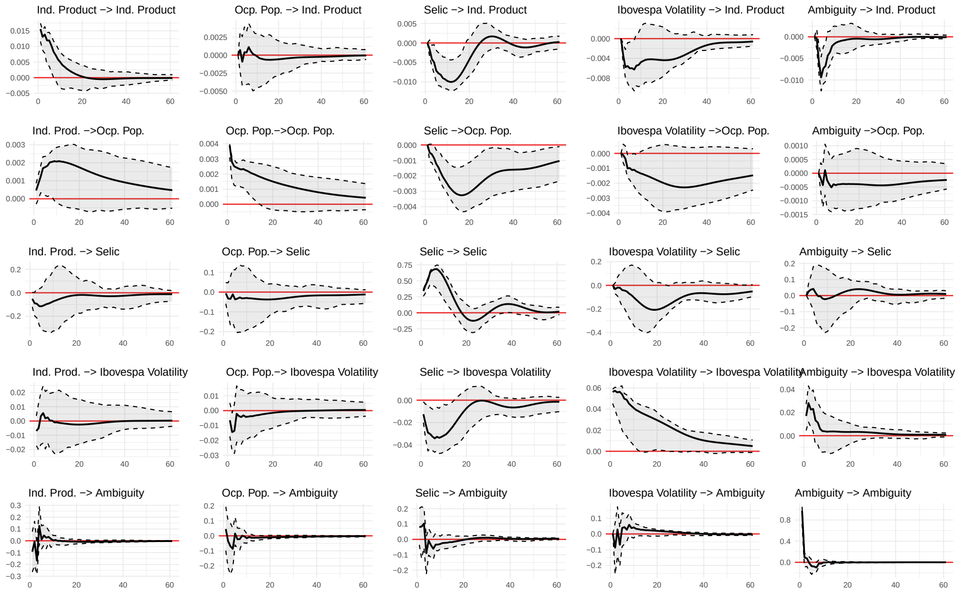


Figure A.37: Impulse Response Functions (k) - SVAR - Industrial Production

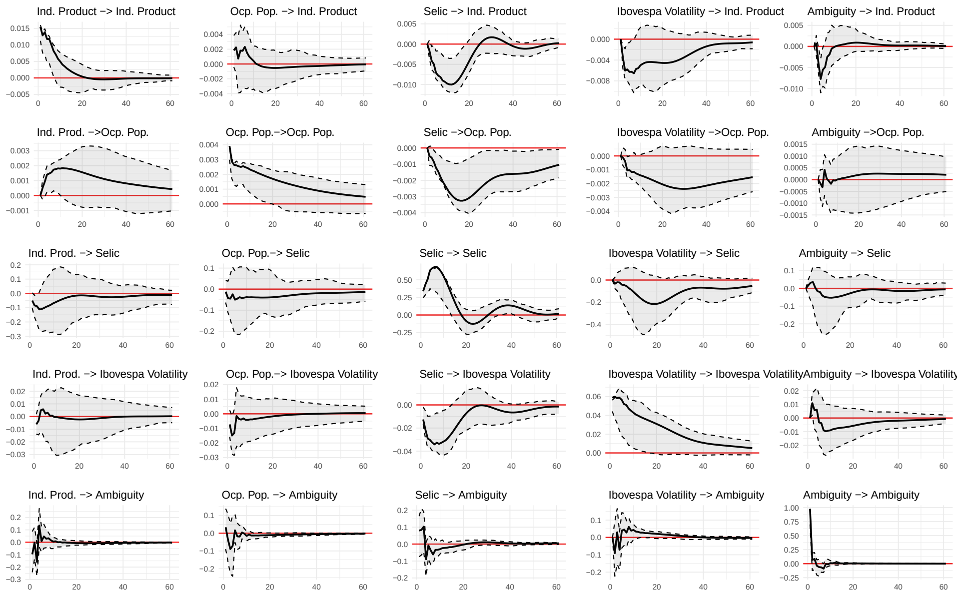


Figure A.38: Impulse Response Functions (l) - VAR - Industrial Production

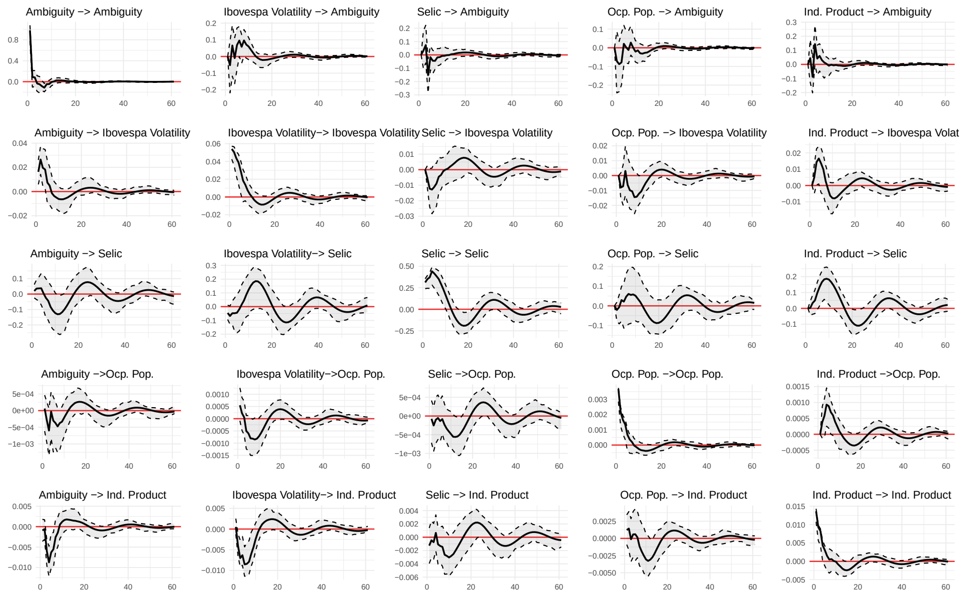


Figure A.39: Impulse Response Functions (l) - SVAR - Industrial Production

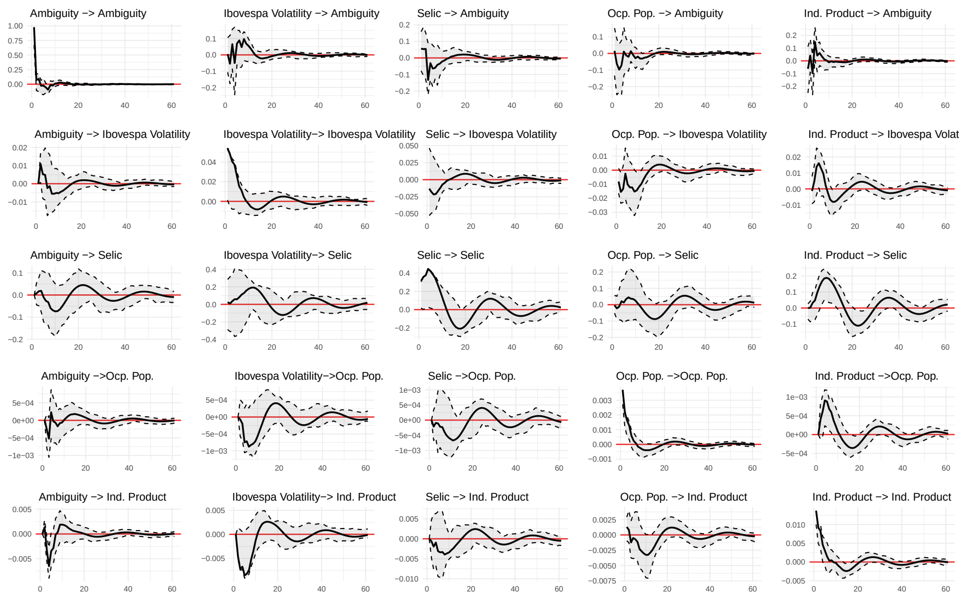


Figure A.40: Impulse Response Functions (i) - VAR - IBC-Br

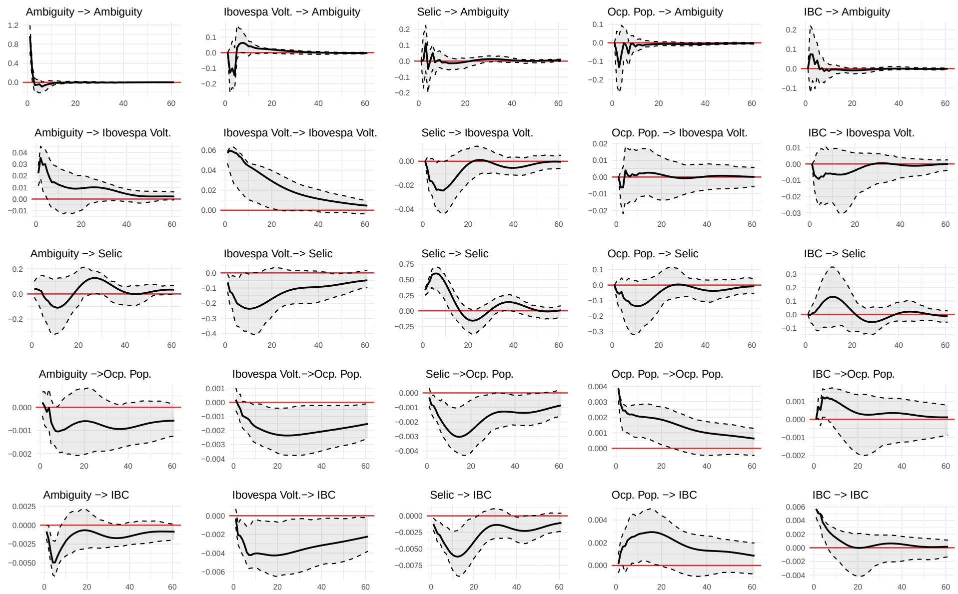


Figure A.41: Impulse Response Functions (i) - SVAR - IBC-Br

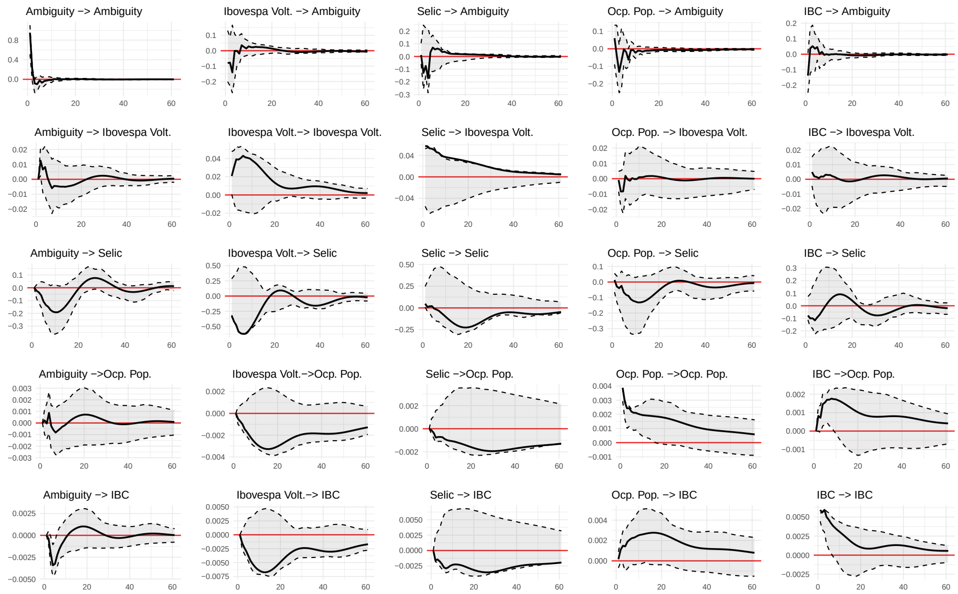


Figure A.42: Impulse Response Functions (ii) - VAR - IBC-Br

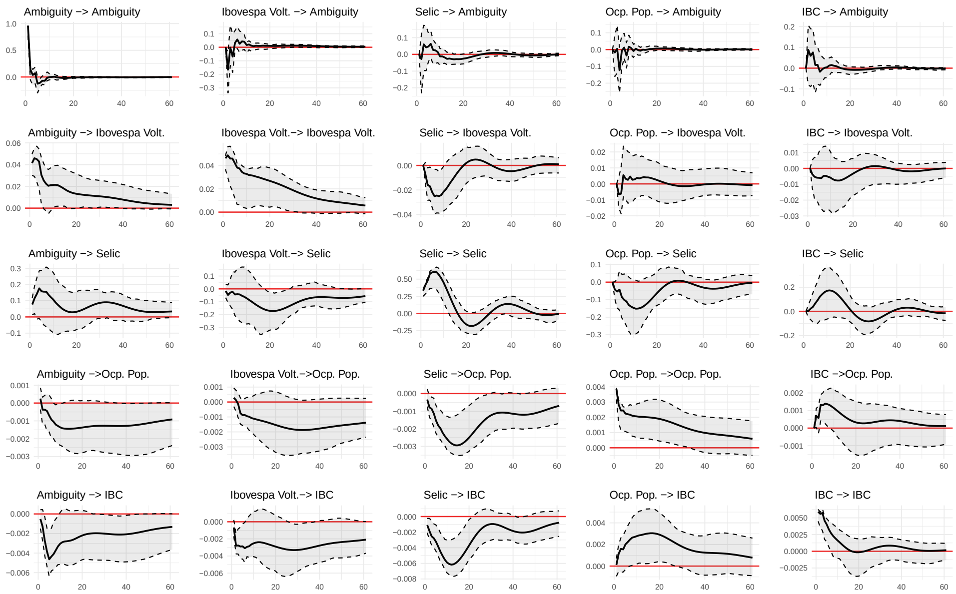


Figure A.43: Impulse Response Functions (ii) - SVAR - IBC-Br

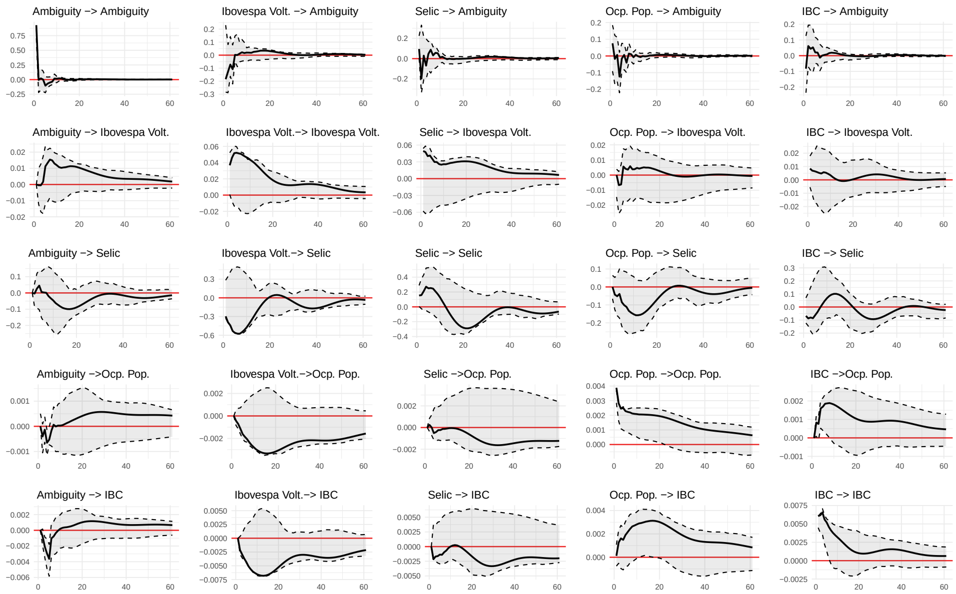


Figure A.44: Impulse Response Functions (iii) - VAR - IBC-Br

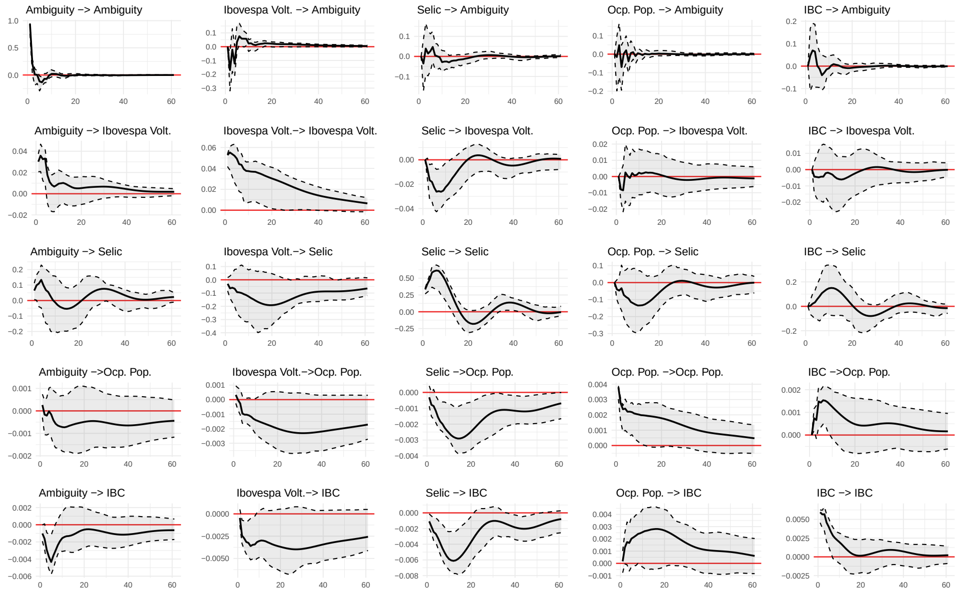


Figure A.45: Impulse Response Functions (iii) - SVAR - IBC-Br

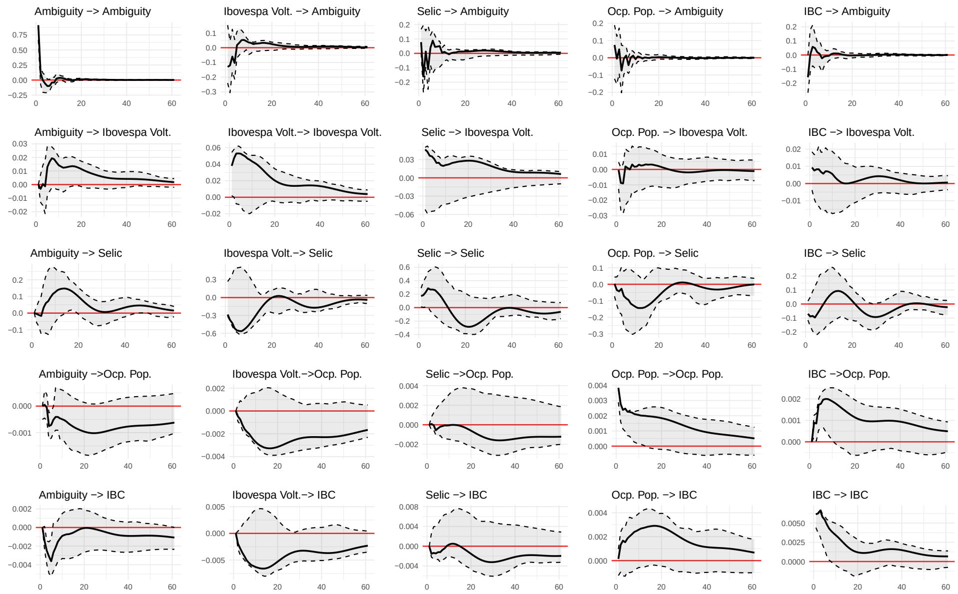


Figure A.46: Impulse Response Functions (iv) - VAR - IBC-Br

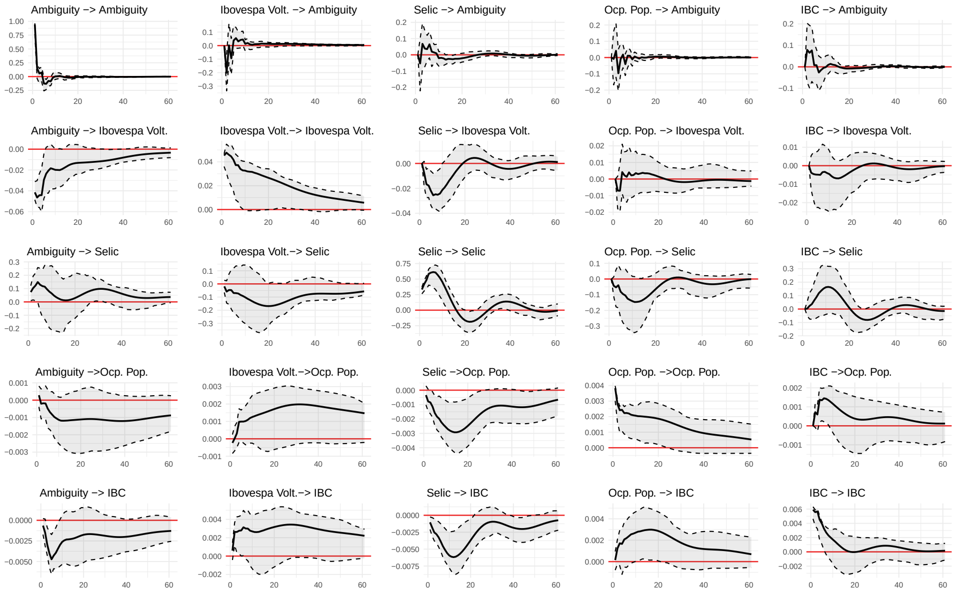


Figure A.47: Impulse Response Functions (iv) - SVAR - IBC-Br

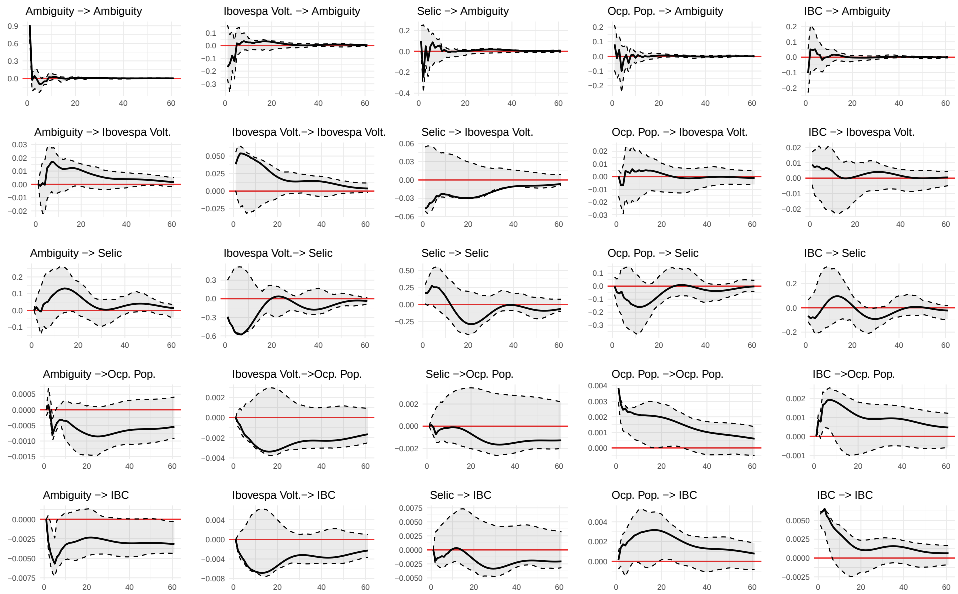


Figure A.48: Impulse Response Functions (v) - VAR - IBC-Br

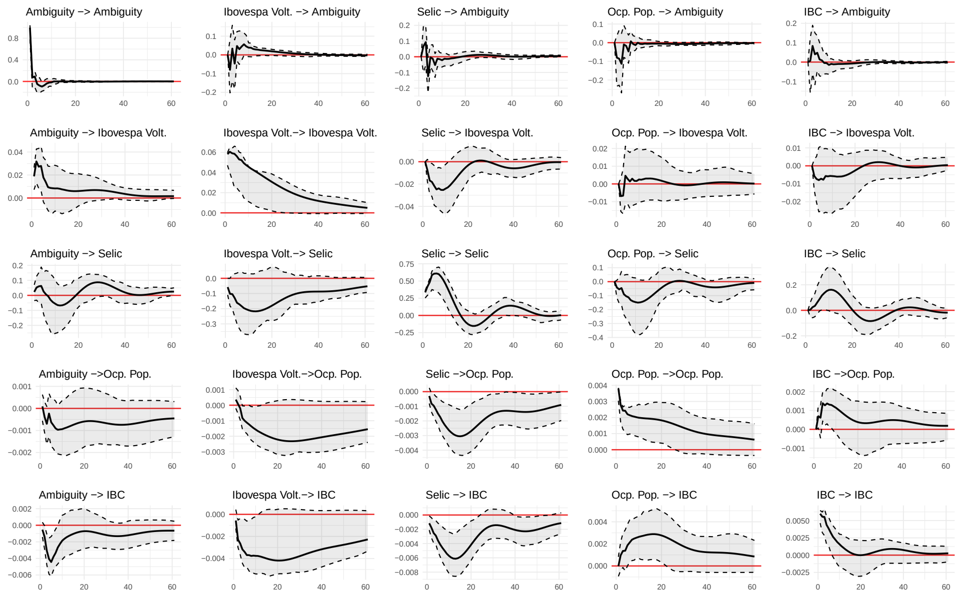


Figure A.49: Impulse Response Functions (v) - SVAR - IBC-Br

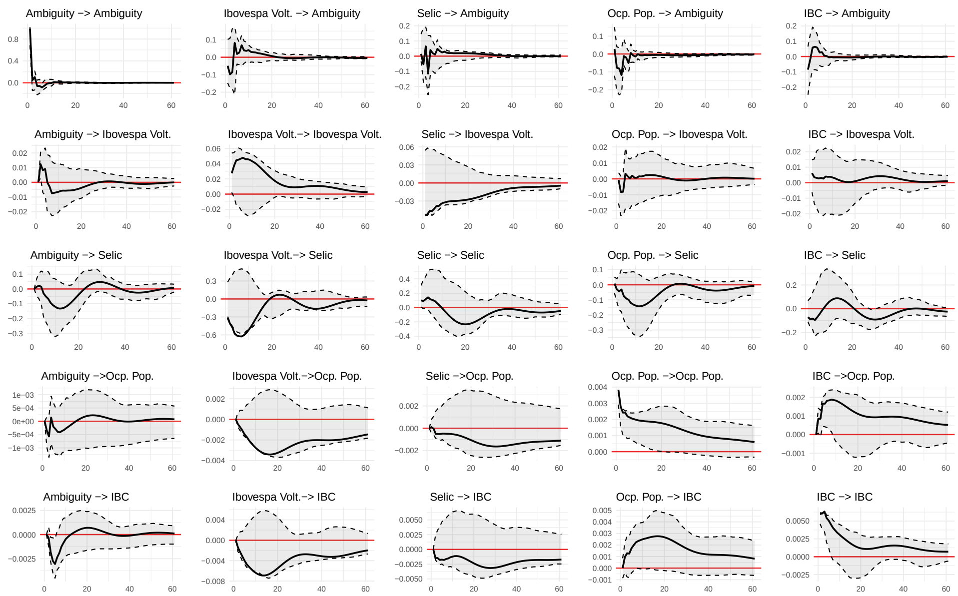


Figure A.50: Impulse Response Functions (vi) - VAR - IBC-Br

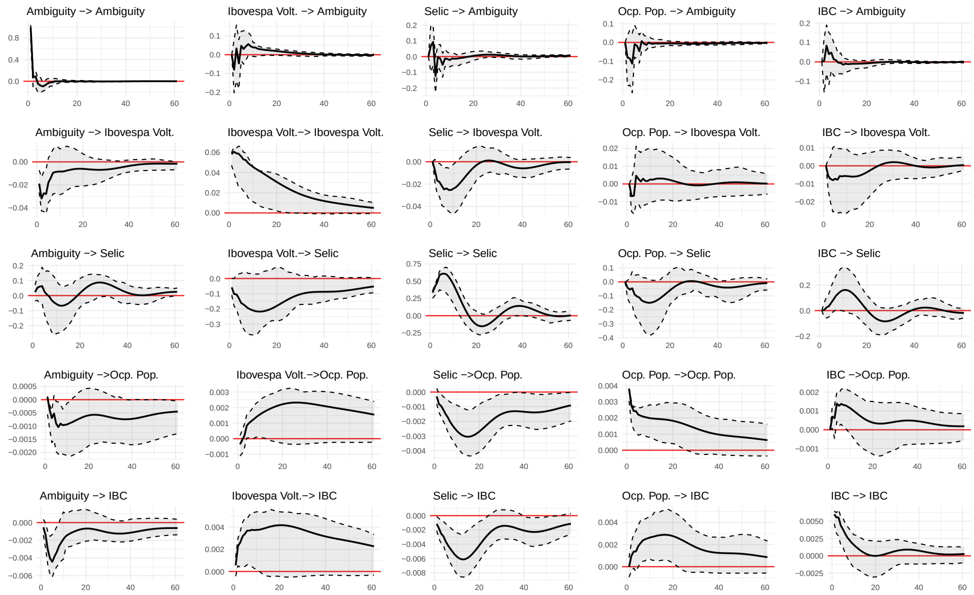


Figure A.51: Impulse Response Functions (vi) - SVAR - IBC-Br

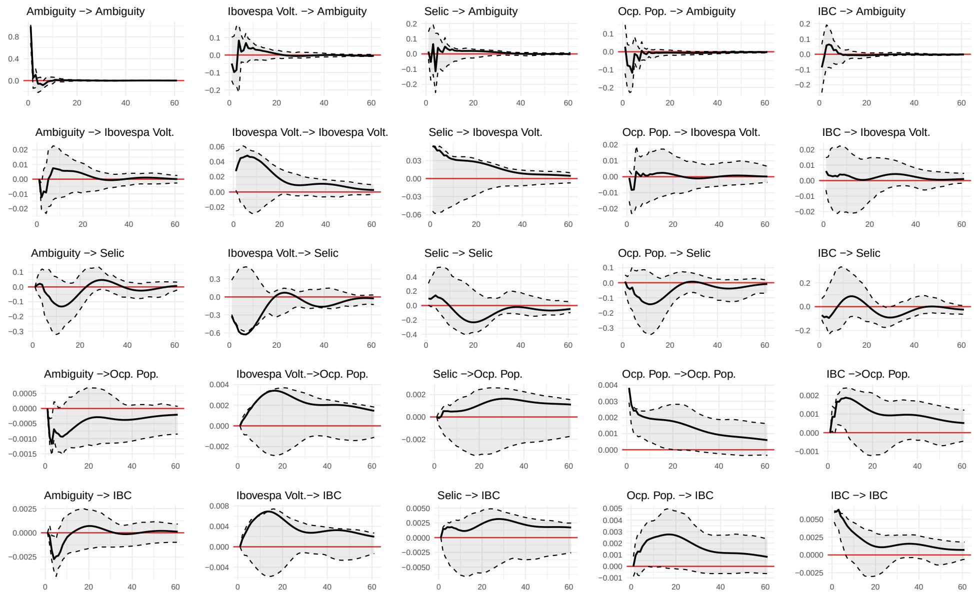


Figure A.52: Impulse Response Functions (a) - VAR - IBC-Br

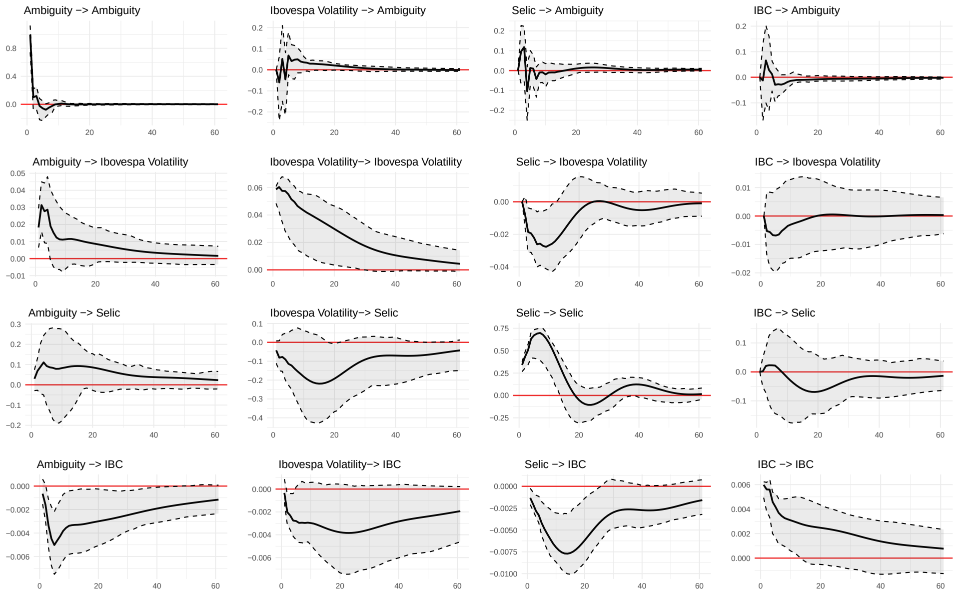


Figure A.53: Impulse Response Functions (a) - SVAR - IBC-Br

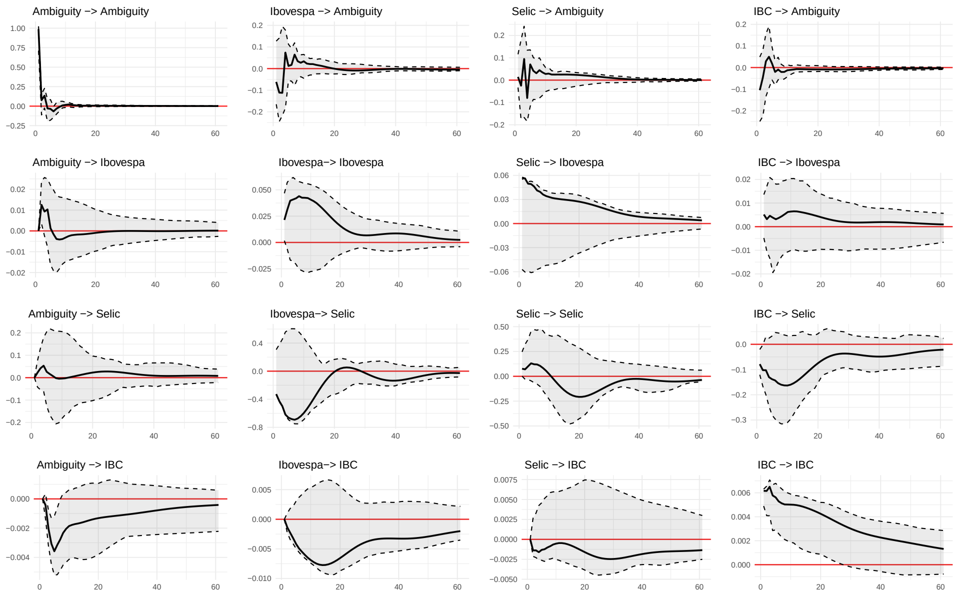


Figure A.54: Impulse Response Functions (b) - VAR - IBC-Br

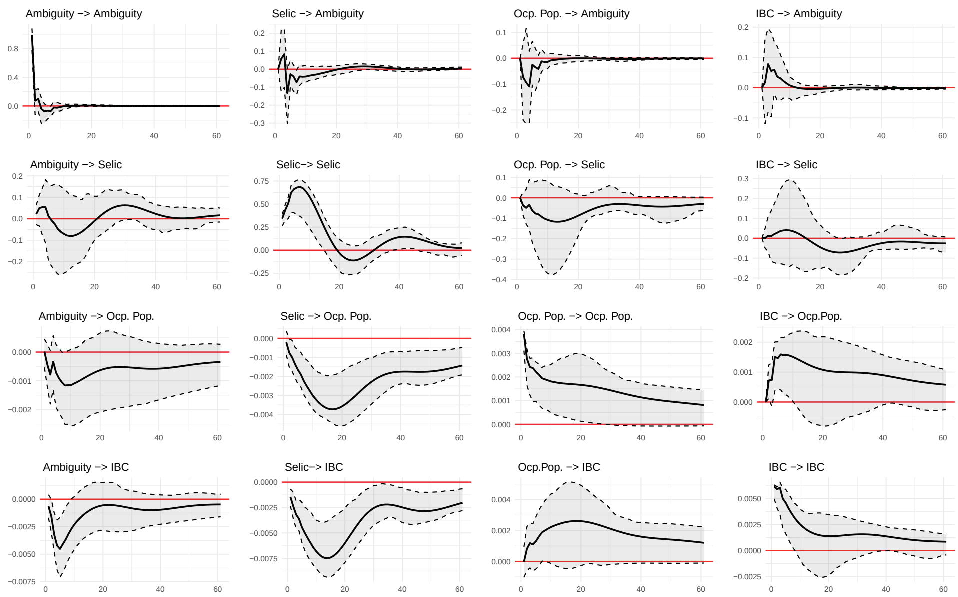


Figure A.55: Impulse Response Functions (b) - SVAR - IBC-Br

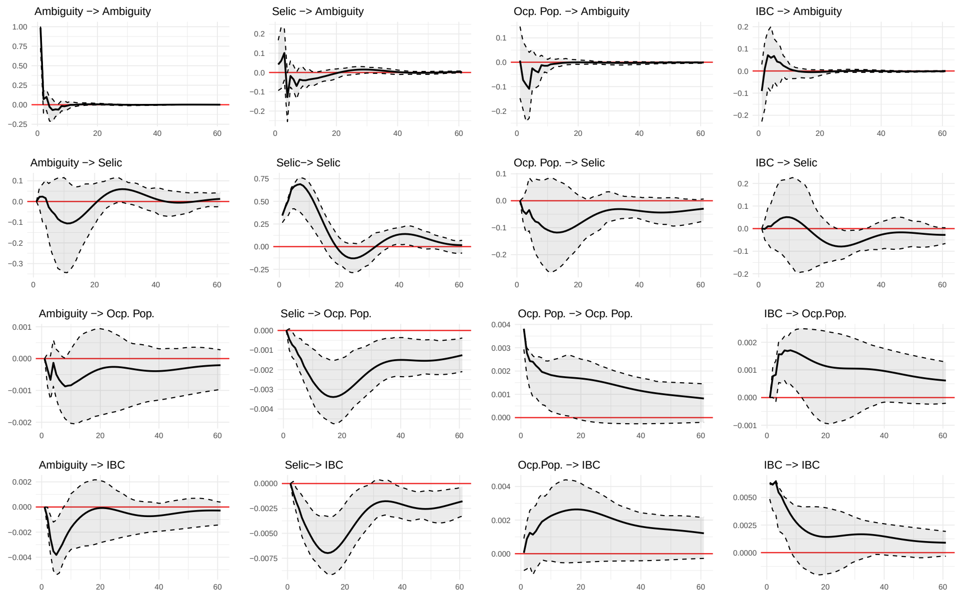


Figure A.56: Impulse Response Functions (c) - VAR - IBC-Br

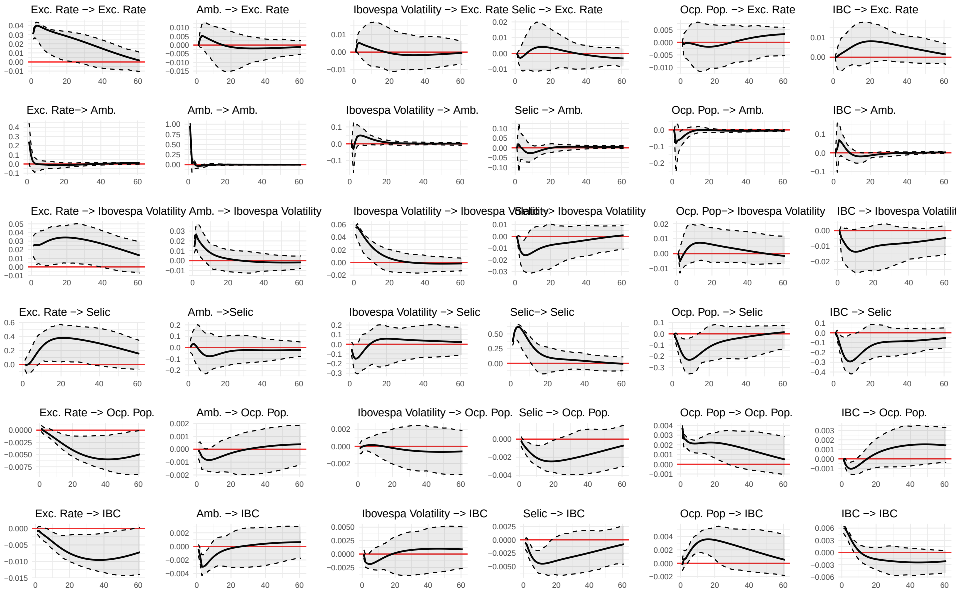


Figure A.57: Impulse Response Functions (c) - SVAR - IBC-Br

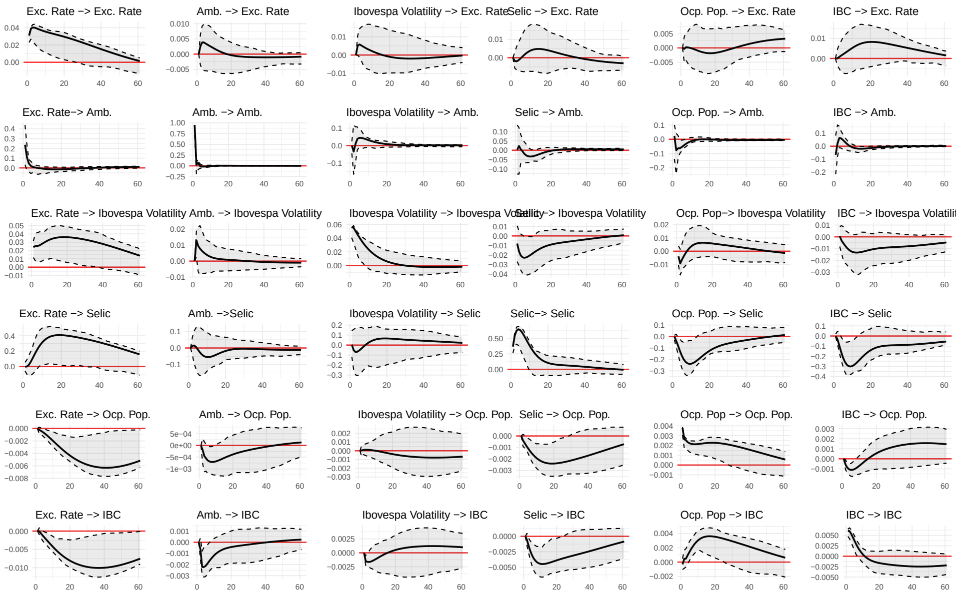


Figure A.58: Impulse Response Functions (d) - VAR - IBC-Br

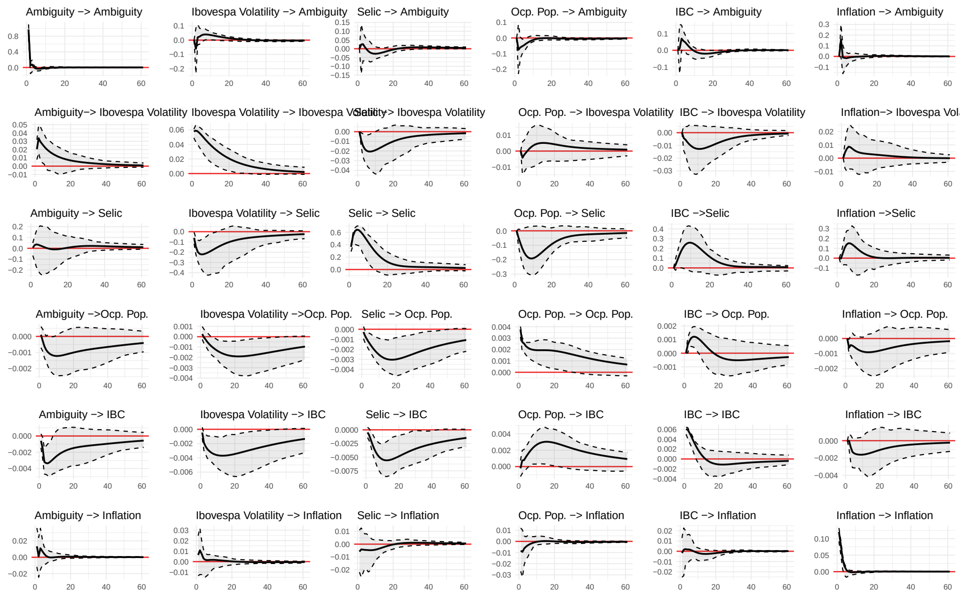


Figure A.59: Impulse Response Functions (d) - SVAR - IBC-Br

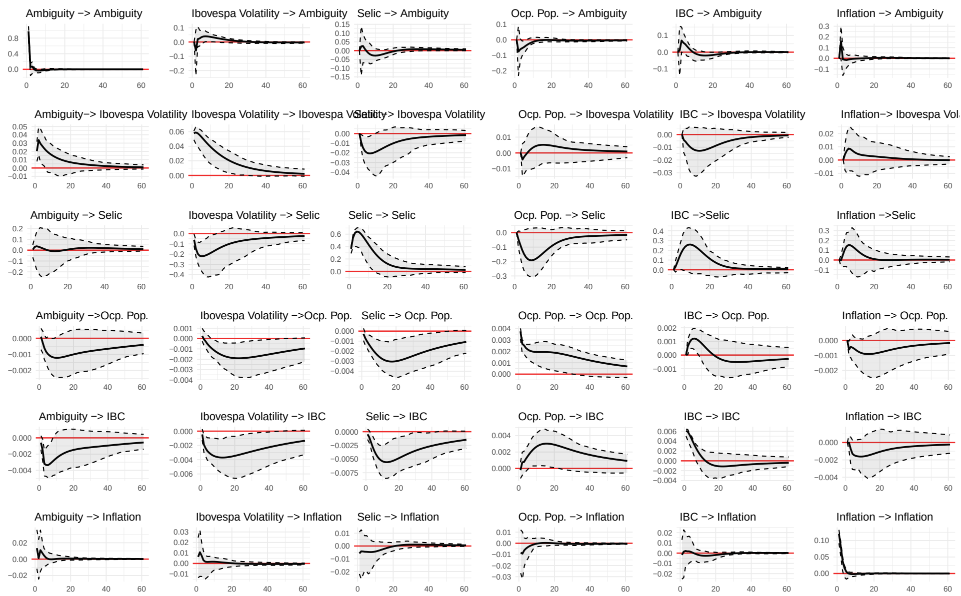


Figure A.60: Impulse Response Functions (e) - VAR - IBC-Br

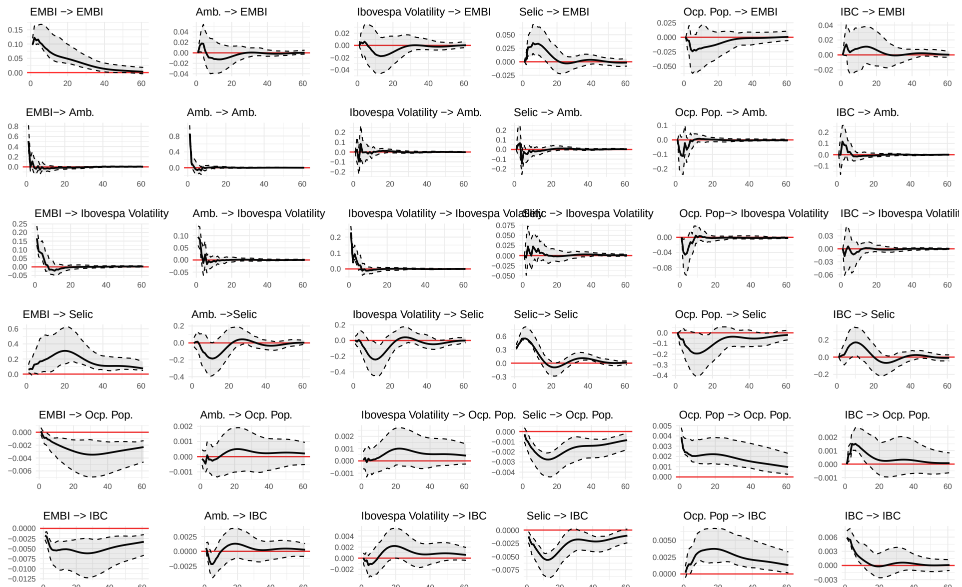


Figure A.61: Impulse Response Functions (e) - SVAR - IBC-Br

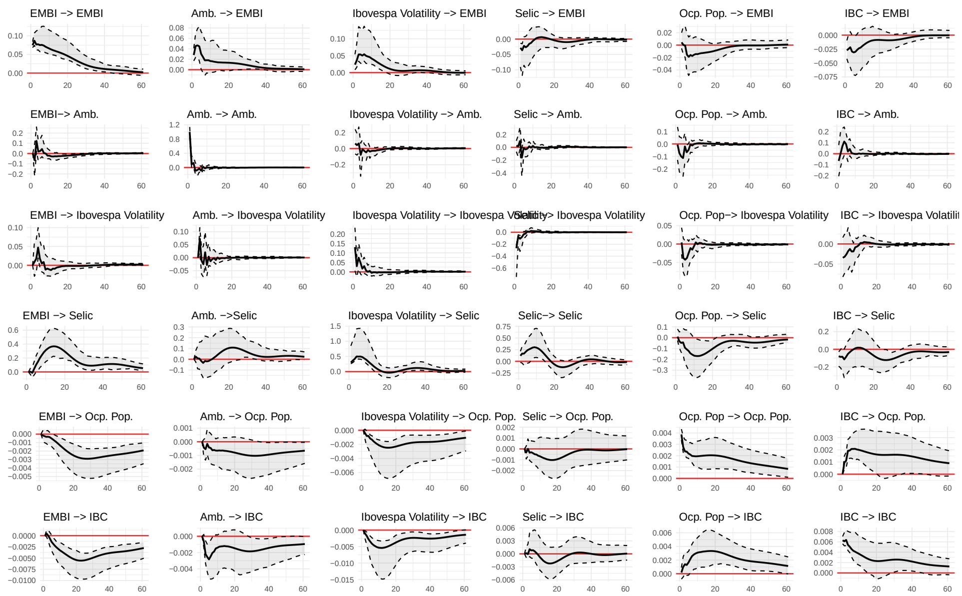


Figure A.62: Impulse Response Functions (f) - VAR - IBC-Br

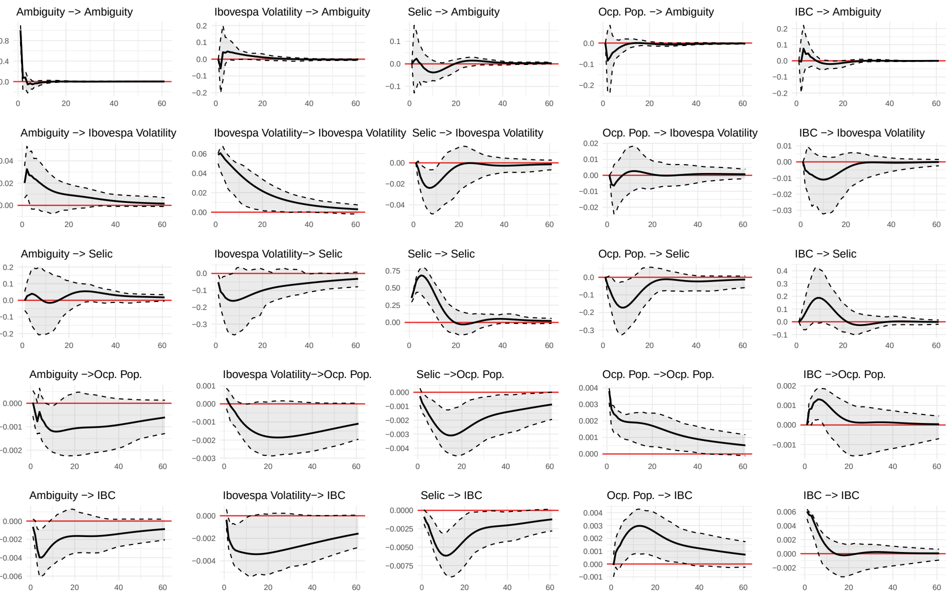


Figure A.63: Impulse Response Functions (f) - SVAR - IBC-Br

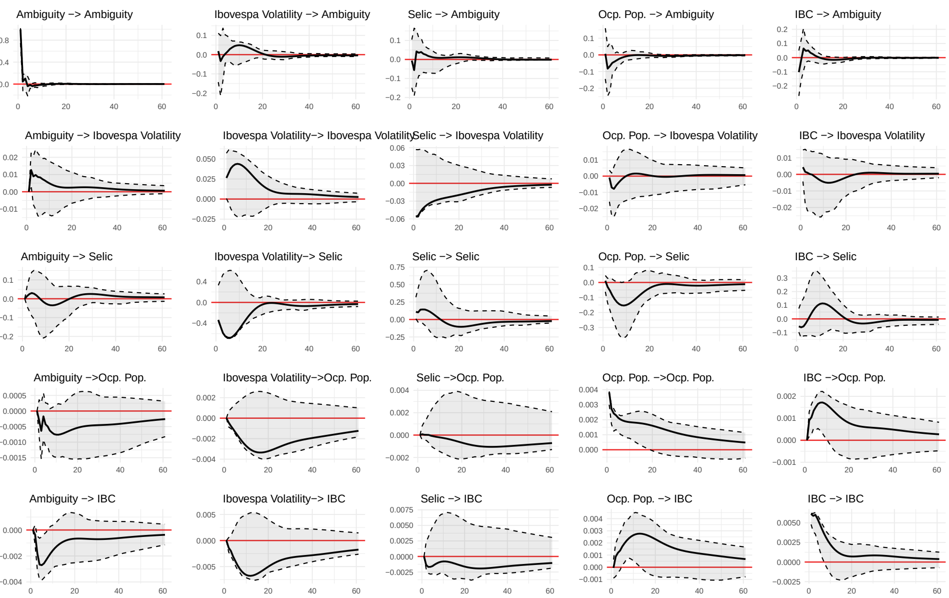


Figure A.64: Impulse Response Functions (g) - VAR - IBC-Br

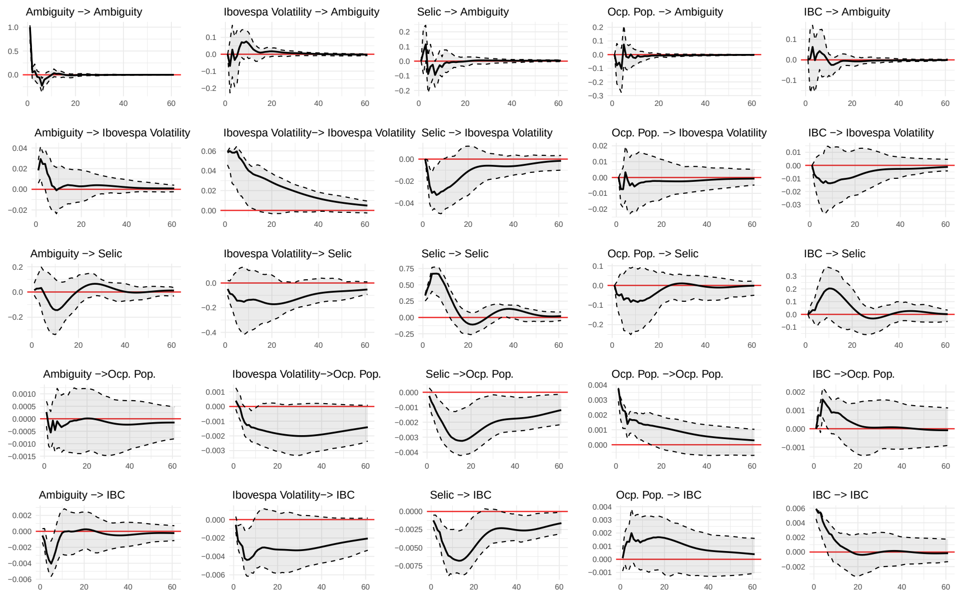


Figure A.65: Impulse Response Functions (g) - SVAR - IBC-Br

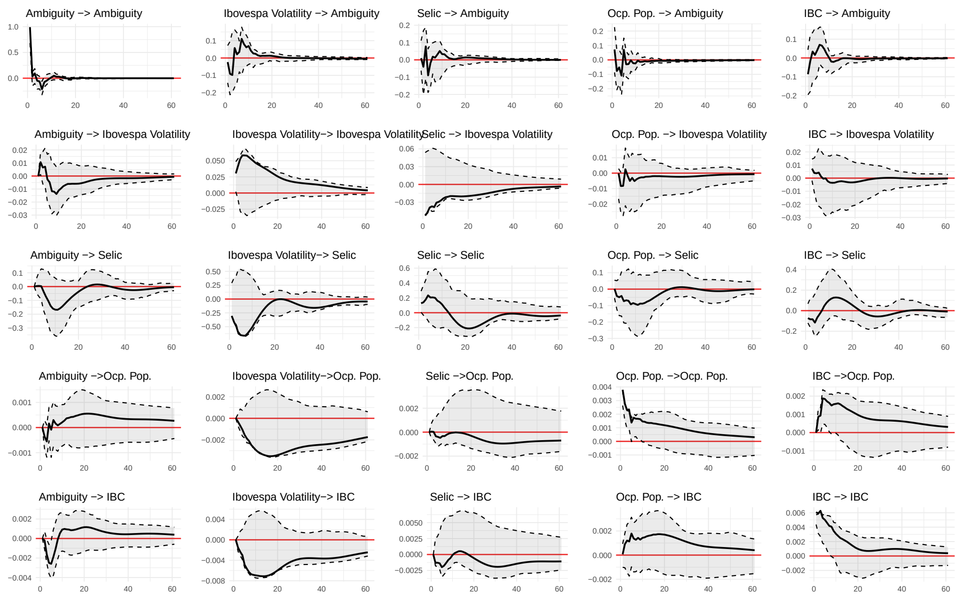


Figure A.66: Impulse Response Functions (h) - VAR - IBC-Br

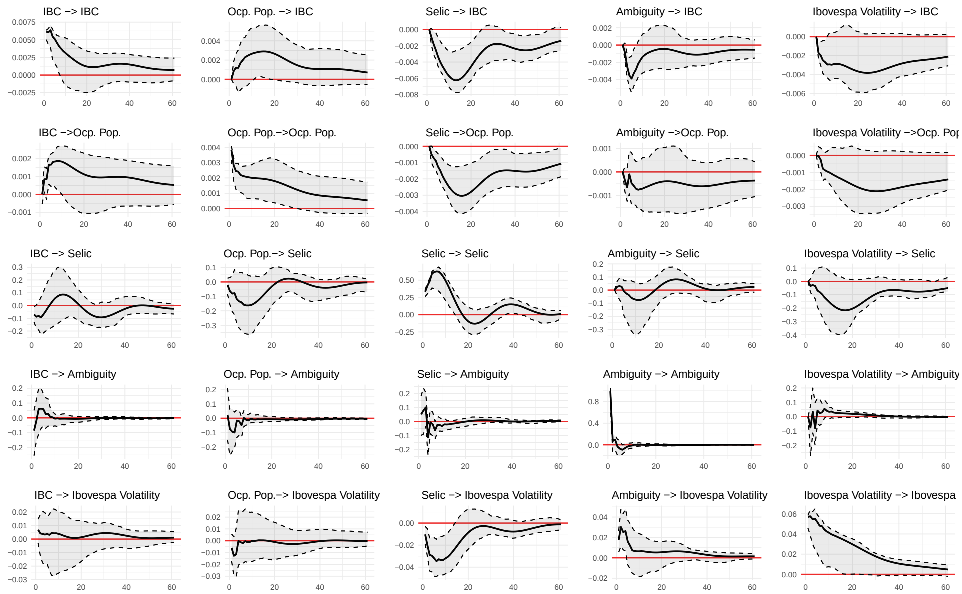


Figure A.67: Impulse Response Functions (h) - SVAR - IBC-Br

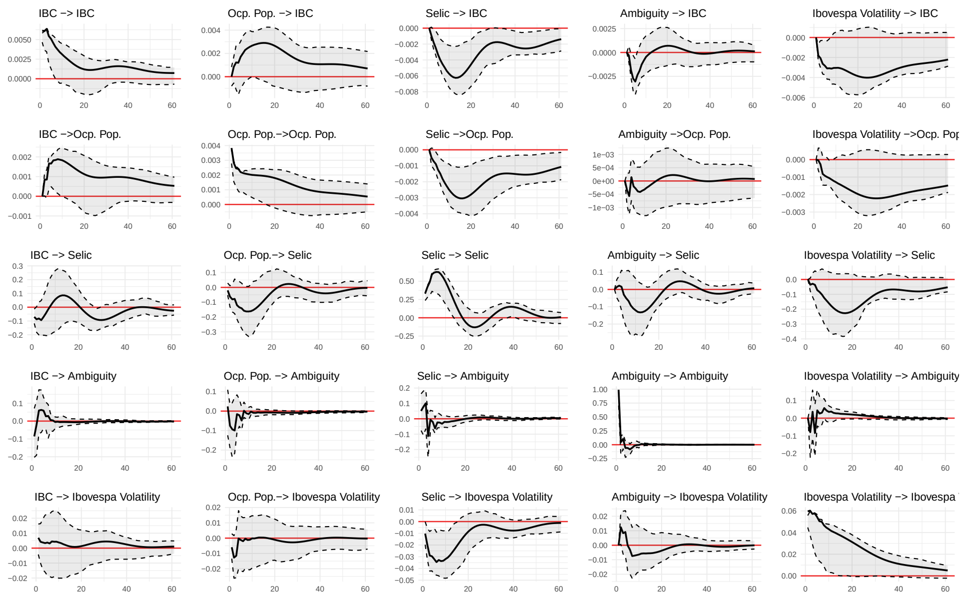


Figure A.68: Impulse Response Functions (i) - VAR - IBC-Br

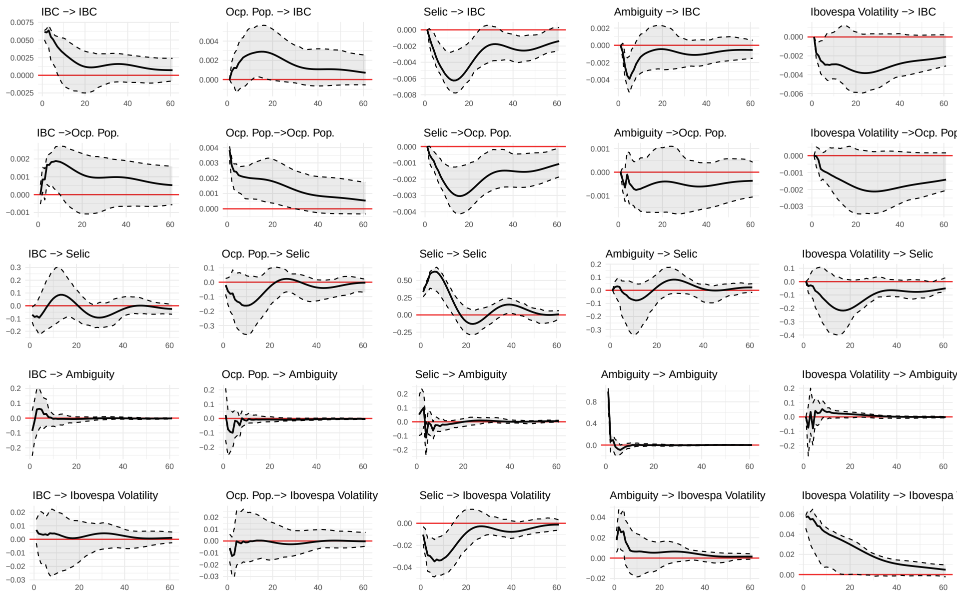


Figure A.69: Impulse Response Functions (i) - SVAR - IBC-Br

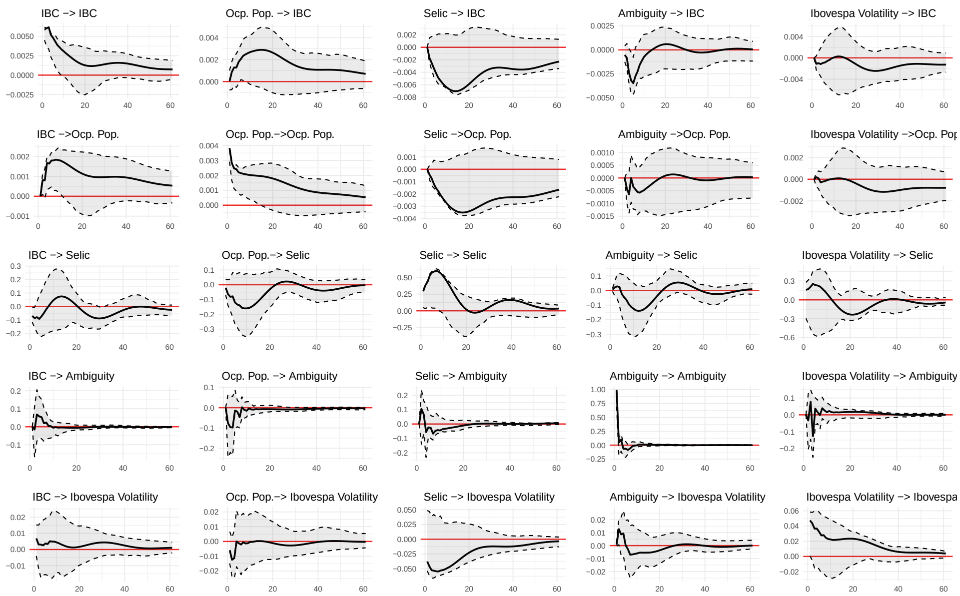


Figure A.70: Impulse Response Functions (k) - VAR - IBC-Br

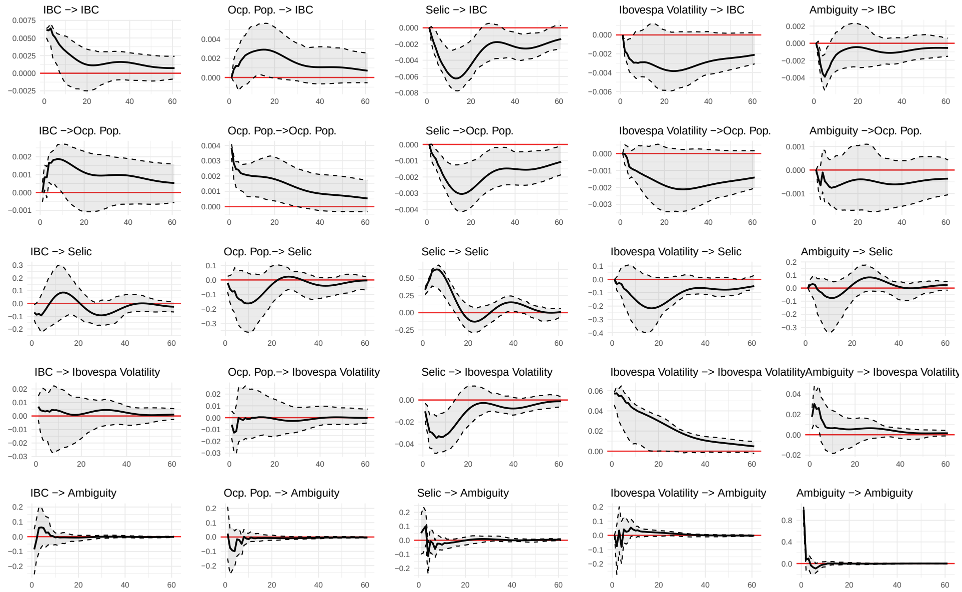


Figure A.71: Impulse Response Functions (k) - SVAR - IBC-Br

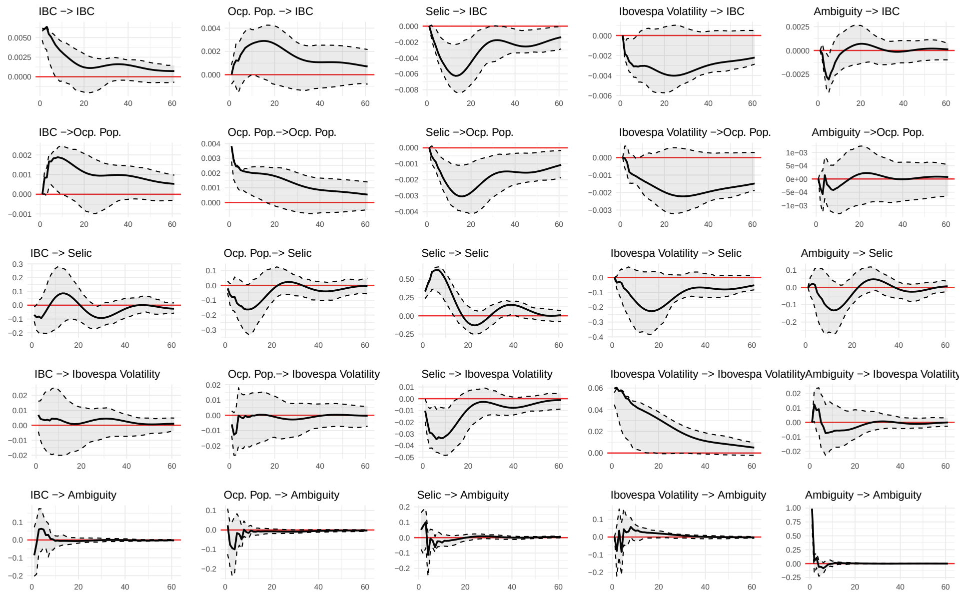


Figure A.72: Impulse Response Functions (l) - VAR - IBC-Br

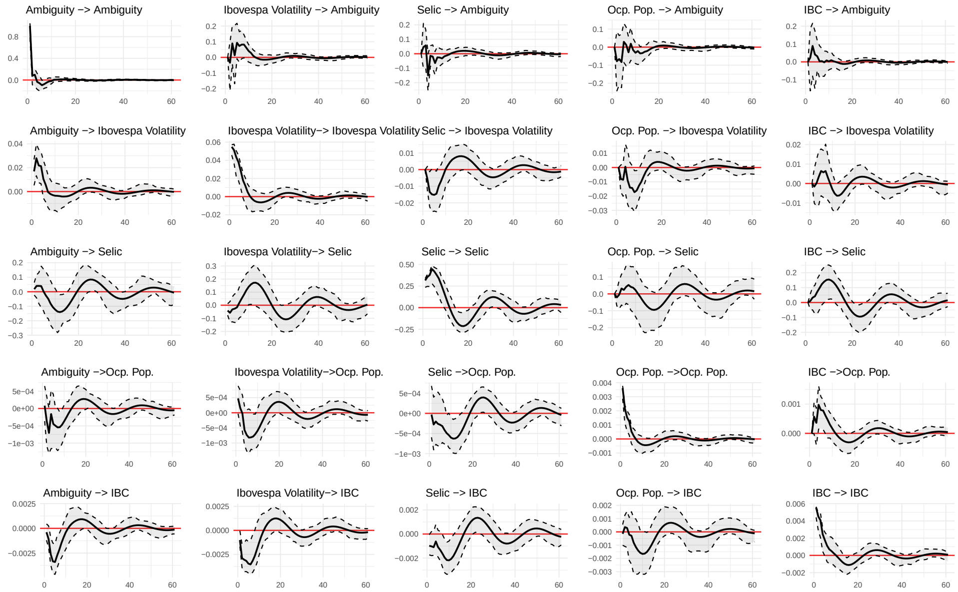
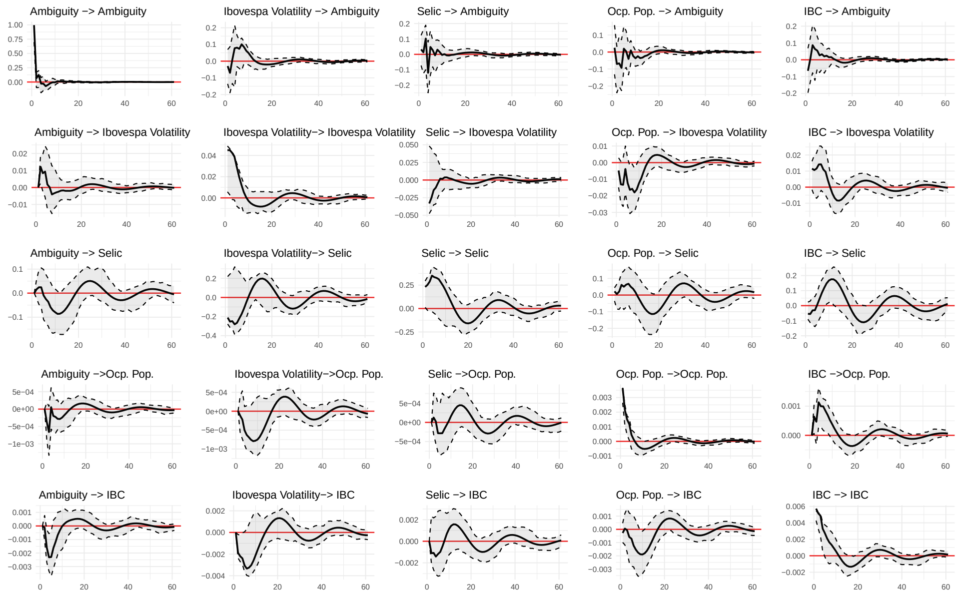


Figure A.73: Impulse Response Functions (l) - SVAR - IBC-Br



Appendix B

Essay 2

Table B.1: Variables

Name	Time	Source	Sample Size
Current Inflation	2003:01-2016:02	IBGE	158
Lagged Inflation	2003:01-2016:02	IBGE	158
Inflation Expectations (t+12)	2003:01-2016:02	BACEN	158
Industrial Product	2003:01-2016:02	BACEN	158
IBC-Br	2003:01-2016:02	BACEN	158
Wage Mass	2003:01-2016:02	IBGE	158
Unemployment Rate	2003:01-2016:02	IBGE	158
Nominal Exchange Rate	2003:01-2016:02	BACEN	158

Note: Variables descriptions, database, time periodicity and specification.

Appendix C

Essay 3

Table C.1: AIC - QR (First Stage)

Quantile	**(1.4)**	**(1.5)**	**(1.6)**
0.01	825.3304	781.4570	836.9642
0.25	329.5607	322.4484	327.6636
0.50	245.0479	229.9900	245.5145
0.75	331.7615	280.6414	326.3046
0.99	825.7177	726.7412	927.6585

Note: Akaike Information Criterion.

Table C.2: Regressions Results - QR (First Stage)

Variable	**Quantile**	**(1.1)**	**(1.2)**	**(1.3)**	**(1.4)**	**(1.5)**	**(1.6)**
	0.01	1.8999*	1.8833*	1.8685*	1.8838*	1.8639*	1.8864*
	0.25	2.1117*	2.1274*	2.1087*	2.1141*	2.0932*	2.1218*
Intercept	**0.50**	2.3234*	2.3233*	2.3371*	2.3272*	2.3158*	2.3347*
	0.75	2.4813*	2.4797*	2.4708*	2.4722*	2.4550*	2.4795*
	0.99	2.6173*	2.5988*	2.6012*	3.1761*	3.0393*	2.8645*
	0.01	−0.0484*	−0.0455*	−0.0434*	−0.0463*	−0.0412*	−0.0463*
	0.25	−0.0377*	−0.0371*	−0.0386*	−0.0375*	−0.0372*	−0.0384*
Latit	**0.50**	−0.0370*	−0.0372*	−0.0370*	−0.0373*	−0.0376*	−0.0368*
	0.75	−0.0365*	−0.0364*	−0.0365*	−0.0366*	−0.0358*	−0.0361*
	0.99	−0.0326**	−0.0409*	−0.0401*	−0.0551*	−0.0418*	−0.0373*
	0.01	−0.0028**	−0.0030**	−0.0023	−0.0032*	−0.0016	−0.0031**
	0.25	0.0011	0.0011	0.0013**	0.0012**	0.0013**	0.0012**
Rain	**0.50**	0.0011*	0.0011*	0.0011*	0.0010*	0.0009*	0.0012*
	0.75	0.0014*	0.0014*	0.0015*	0.0014**	0.0011	0.0017*
	0.99	0.0061**	0.0061**	0.0062**	−0.0020	−0.0012	0.0027
	0.01	−0.5619					
	0.25	0.1278					
Slaves	**0.50**	0.0632					
	0.75	0.0064					
	0.99	0.3724					
	0.01		1.9155				
	0.25		0.4336				
Immig	**0.50**		−0.0238				
	0.75		−0.4537				
	0.99		−2.4412				
	0.01			−132.0548			
	0.25			−231.0930			
Judges	**0.50**			−128.4262			
	0.75			9.9756			
	0.99			−53.7617			
	0.01				9.8448		
	0.25				9.8408**		
Milit	**0.50**				4.8501**		
	0.75				2.8403		
	0.99				22.3396**		
	0.01					−0.0069	
	0.25					0.0015	
D.Density	**0.50**					0.0031**	
	0.75					0.0066*	
	0.99					0.0179*	
	0.01						−0.6234
	0.25						−5.3840**
LandHold	**0.50**						−5.3450
	0.75						−6.4246*
	0.99						50.5969**