Banco Central de Chile
Documentos de Trabajo

Central Bank of Chile
Working Papers

N° 637

Agosto 2011

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Juan Pablo Medina

Alberto Naudon

BANCO CENTRAL DE CHILE

CENTRAL BANK OF CHILE

Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
Agustinas 1180, Santiago, Chile
Teléfono: (56-2) 3882475; Fax: (56-2) 3882231

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LABOR MARKET DYNAMICS IN CHILE: THE ROLE OF TERMS OF TRADE SHOCKS

Juan Pablo Medina
Banco Central de Chile

Alberto Naudon
Banco Central de Chile

Abstract

In this paper we explore the channels through which the terms of trade affect labor market variables in an emerging economy such as Chile. In doing so, we analyze the cyclical properties of labor market variables and use a structural vector autoregressive model to analyze the empirical responses of variables such as unemployment rate, job finding rate, sectoral employment and sectoral average labor productivity to terms of trade shocks in the case of Chile, which come from two main sources: the mining and the non-mining sector. We then develop a multi-sector model with search frictions that generates fluctuations in the unemployment rate. Using a calibrated version of this model for Chile, we analyze the ability of the model to replicate the observed responses of labor market variables to terms of trade shocks. We find that the model can predict quantitatively the effects of labor market variables to non-mining terms of trade shocks. Although the model is able to obtain responses to mining price changes qualitatively similar to what is estimated in the data, it falls short to the estimated magnitude of reduction in unemployment that follows a rise in mining prices. The presence of very high wage rigidity can help to generate a sharper fall in unemployment after a mining terms of trade rise. Finally, the model remarks a more intense sectoral labor reallocation in response to terms of trade shocks than the amount estimated in the data.

Resumen

En este trabajo exploramos los canales a través de los cuales los movimientos de los términos de intercambio afectan las variables del mercado laboral en una economía emergente como la chilena. Para ello analizamos las características cíclicas de las variables del mercado laboral y utilizamos un modelo de vector autorregresivo (VAR) para analizar las respuestas empíricas de variables tales como la tasa de desempleo, el tiempo promedio que un desempleado demora en encontrar trabajo, el empleo sectorial y la productividad media del trabajo sectorial a las fluctuaciones de los términos de intercambio en el caso de Chile. Dichas variables provienen de dos fuentes principales: el sector minero y el no minero. A continuación, desarrollamos un modelo multisectorial con fricciones de búsqueda que genera fluctuaciones en la tasa de desempleo. Usando una versión de este modelo calibrado para Chile, analizamos la capacidad del modelo de replicar la respuesta observada de las variables del mercado laboral a los movimientos de los términos de intercambio. Encontramos que el modelo puede predecir cuantitativamente bien los efectos de las variables del mercado laboral a los términos de intercambio no mineros. Aunque el modelo puede obtener respuestas a los términos de intercambio mineros cualitativamente similares a lo estimado en los datos, registra una menor reducción en el desempleo después de un aumento en los términos de intercambio mineros. La presencia de alta rigidez de salarios puede ayudar a generar caídas más fuertes en el desempleo después de que los términos de intercambio mineros aumentan. Finalmente, el modelo muestra una reasignación de empleo sectorial en respuesta a los términos de intercambio de magnitud mayor que la estimada en los datos.

We thank comments by Raphael Bergoeing, Robert Shimer and participants of labor market workshop organized by the Central Bank of Chile in November of 2010. All errors are our responsibility. E-mails: jmedina@bcentral.cl and anaudon@bcentral.cl .

1 Introduction

The unemployment rate is one of the most popular figure to assess the overall labor market conditions. More generally, unemployment is indicative of both economy's production capacity and aggregate spending. A lower unemployment rate translates into more employed individuals with labor income, which may reflect into higher consumer spending and economic growth. Conversely, high levels of unemployment are associated with lower incomes, lower spending, and low economic growth. Moreover, the unemployment rate is also used as a measure of the degree of slackness of the economy which, in turn, might imply an expected path for prices and wages in the future. In the case of Chile like other emerging economies, the unemployment rate has experienced significant fluctuations in the last three decade. These movements have been triggered or influenced by changes in the external conditions. Among the external variables, the terms of trade are an important source of business cycles in the case of Chile, which reflects the relevance of the price of exports for the economy's performance.

In order to illustrate the volatility of the unemployment rate in an emerging economy like Chile, figure 1 shows the evolution of the unemployment rate in Chile since 1986, which it has fluctuated between 6% and above 10% in last twenty years, a period marked with strong economic growth and lower output volatility.

In this context, the purpose of this work is to analyze the relationship between the terms of trade and the variables that describe the labor market in Chile, especially, the unemployment rate. In doing so, we first provide evidence of the cyclical behavior and the response of the labor market to terms of trade shocks. Second, in order to shed light on the mechanisms behind this responses we extend the search friction real business cycle model in Shimer (2010a) to an small open multi-sector economy setting calibrated for the Chilean economy. Given the importance of mining exports in Chile, we study separately the role of mining and non-mining term of trade effects in labor market variables.

Our empirical evidence shows that terms of trade shocks exerts significant effects on the unemployment rate. The behavior of the unemployment rate after terms of trade fluctuations are related to both changes in the job finding rate and in the job destruction rates. Estimated impulse responses show that unemployment rate increases with higher non-mining export prices, although the effects are not statistically significant at standard levels. Regarding the effects of mining terms of trade, the impulse response shows that the unemployment rate decreases significantly.

The model –calibrated for the Chilean economy– is able to generate responses of labor market variables to non-mining terms of trade shock in line with the empirical evidence for Chile. However, the model predictions after an increase in mining terms of trade are not able to generate the magnitude of the reduction of unemployment rate.

Using the model, we also explore the importance of rigid wages in unemployment dynamics, an issue that has been highlighted by Hall (2005) and Shimer (2005) among others as a critical elements to explain the high volatility of unemployment rate in the United States. Wage rigidity in terms of importable is better equipped to induce fluctuations to unemployment rate after terms of trade shocks in the the direction and magnitude as is observed in the data. However, the responses of the labor market variables after a rise in mining price are smaller that their empirical counterpart. This result calls the attention to additional channels omitted in the present model through which mining price movements can have sizeable effect in business cycles as is observed in the data for Chile. In this context, an extreme wage rigidity coupled with a fall in the job separation rate can amplify significantly the model predictions after mining terms of trade shocks, resembling more closely the empirical evidence. However, at the same time, an extreme wage rigidity induces too much reaction after non-mining terms of trade shocks, which is a feature not observed in the data.

It is important to mention some limitations in the present analysis. Although our model is medium size due to the multi-sectoral framework, it is still imperfect to characterize all relevant features that describe the Chilean business cycle in the last twenty five years. Nevertheless, our model offers a framework to understand some labor market variables that are not usually considered in aggregate macroeconomic analysis in Chile such as job finding rate. Moreover, despite of the limitations we think our model is valuable to explore the channels to which terms of trade shocks affect labor market variables without imposing excessive structure. Finally, the model variants considered here do not pretend to capture the structural ingredients behind wage rigidity and limitation to the international financial markets; rather, they are used to illustrate simply how these possibilities modify the labor market dynamics in response to terms of trade fluctuations.

The structure of the paper is as follows. In the next section, we provide empirical evidence for the cyclical behavior of labor market variables in Chile and their response to terms of trade shocks. Section three lays out a multi-sector model with search frictions for a small open economy. A calibration of the model for the Chilean economy is presented in section four. Simulations of the baseline model and other variants after terms of trade shocks are analyzed in section five in comparison with the empirical evidence. Section six ends with final remarks.

2 Some facts about Chilean labor markets

In this section we review several aspects of the Chilean labor market data. Data is quarterly and the sample period is 1989 to 2009, unless otherwise stated.[1] We start analyzing unconditional moments. To put our numbers in perspective, we first review some aggregate statistics that allow us to compare the Chilean labor market statistics with those observed in other countries.[2] Then, we explore in more detail the interaction of labor market variables with international prices by analyzing the impulse response functions obtain from an structural vector autoregression (SVAR).

Since the focus of our investigation is the relationship between the behavior of labor market variables and international prices, we study separately the importance of the price of mining exports and the price of non-mining exports, both deflated by the price of imports. In principle, it is reasonable to conjecture that both prices have different effects on the labor market, since changes in the former involve mostly *income effects*, while the latter directly modify relative prices across productive sectors.

In the construction of sectoral employment data, the exportable sector includes agriculture, fishing and manufacture sectors, while the non tradable sector are the others except mining. The exclusion of the mining employment in the tradable employment is consistent with the theoretical model developed below, where mining sector is treated as an exogenous endowment. We do this because even though mining sector represents a large share of Chilean output (around 10% of nominal GDP on average during the years included in our sample), it uses only a small share of employment and its production can be treated as independent of domestic macroeconomics conditions. Terms of trade are constructed using the corresponding export and import deflators. Labor market data is from *Instituto Nacional de Estadísticas* (INE).

2.1 Unconditional moments

Unemployment rate and vacancies: As mentioned above, figure 1 shows the evolution of the unemployment rate in Chile during the period going from the first quarter of 1986 to the last quarter of 2009. During the last 25 year, the unemployment rate has fluctuated between 5.7% and 13.6%, with an average level of 8.5% and a standard deviation of 1.6%. The unemployment rate steadily declined from the beginning of the sample until the end of

[1]For many of the series studied in this section there is data starting in 1986. However, import and export deflator indexes start in 1989.

[2]For a more detail description of Chilean labor market see Cowan, Micco, Mizala, Pagés, and Romaguera (2005) and Jones and Naudon (2009).

the nineties, when the unemployment rate reached its lower level around 6%. This period coincides with the so called "golden age" of Chilean growth, a period with an average annual growth rate around 7%. During 1999, as results of the Asian Crises the Chilean economy went into a recession and the unemployment rate increased over 10%. Surprisingly for most of the analysts, its level remained around 10% for the next several years.[3] Only after 2005 the unemployment rate starts to decline, reaching values below 7% during 2007. With the onset of the global financial crisis of 2008 the unemployment rate increased again, breaking the barrier of 10%.[4]

Table 1 shows some business cycle statistics. All data is expressed as log - deviation with respect to its respective HP - trend with a smoothing parameter equal to 1600. The first column shows the standard deviation of the cyclical component of the series. The second column is the auto - correlation. The other columns show the correlation with some selected variables $y = \{$average labor productivity, output, mining terms of trade and non - mining terms of trades$\}$. In each case, we report the contemporaneous correlation with the variables selected in y (the first number in the corresponding column) and the lag (positive integer) or lead (negative integer) of the variable in y that reaches its highest correlation in absolute value. Numbers in parenthesis are the value of this correlation, if there is no data means that the highest correlation is the contemporaneous one.

The table shows that the unemployment rate is very volatile: seven times more volatile than average labor productivity and six times more volatile than output. It is also as persistent as labor average productivity and highly negative correlated with both labor productivity (-.47) and output (-.69). The unemployment rate lags labor productivity by two quarters and output by one. This behavior is similar to the one observed in other economies. For example, Hornstein, Krusell, and Violante (2005) reports that unemployment rate in the United States is about ten times more volatile than labor productivity with a negative correlation with output equal to -.29. Boz, Durdu, and Li (2009) reports that other commodity exporters like Australia, Canada and Norway, have similar relative volatilities of unemployment and output.[5]

The cross correlations of the unemployment rate, and some other macroeconomics variables, with both series of international prices are draw in figures 2 and 3, where the grey area

[3]See Cowan, Micco, Mizala, Pagés, and Romaguera (2005) for a detail description of the dynamic of unemployment rate in Chile during the last decades. See also Bergoeing and Morandé (2002) for an explanation of the increase in the unemployment rate after 1999 based on change in labor market legislation.

[4]During 2010 the unemployment rate has reduced rapidly. We do not consider this data in our study since at the beginning of 2010 the methodologies to construct labor statistics changed and there is not an official splice of the new statistics with the previous ones.

[5]However, in their sample Chile has a relative lower volatility of unemployment rate: 3.7 times the output volatility.

between -.2 and .2 is usually used as a reference for non significant correlation (in statistical terms). The cyclical component of the unemployment rate is positively correlated with the contemporaneous cyclical component of the non - mining terms of trade, and negatively correlated with mining terms of trade, however, neither of these correlations are significant at standard statistical levels. Nevertheless, lags of mining terms of trade are significantly negative correlated with the unemployment rate - reaching a maximum absolute value of -.47 with the third lag. Also, lags of non - mining terms of trade are negatively correlated with the unemployment rate. From the figure it is clear that both terms of trade tends to lag reductions in the unemployment rate, though the effects of mining terms of trade are larger than the effects of non - mining terms of trade.

Vacancies (measured as percentage of working population) are as volatile as unemployment rate and the correlation (not shown in table 1) between this two series is about .60. As expected, vacancies are also highly positively correlated with both labor productivity (.53) and output (.72). The numbers are similar to those reported for US by Hornstein, Krusell, and Violante (2005). More interesting from our perspective, table 1 and figures 2 and 3 show that the number of vacancies are also positive correlated with both measures of international prices, though current correlation with non - mining terms of trade is zero. As it is the case with the unemployment rate, the behavior of the number of vacancies is more correlated with the mining terms of trade than with the non - mining terms of trade.

Wages: We present two series of real wages: Nominal wages deflated by CPI and nominal wages deflated by the price of imports. The reason is that the first is the most common measure of real wages and the second is the one consistent with the model presented below, where the price of imports is the numéraire. Both measures of real wages are less volatile than the unemployment rate, but when deflated by import prices, wages are five times more volatile than when CPI is used. Despite of the differences in volatility, both series share the same a low contemporaneous correlation with productivity and output. However, in both cases there is significant and positive correlation with lags of both productivity and output.

Regarding the correlation with international prices, table 1 shows that both series of real wages are positive correlated with both measures of terms of trade. In both cases data shows that movements of wages tend to lead changes in international prices, since the highest correlation is reached with the first lead of both series of terms of trade.

When compare with other countries, Chilean labor wages ranked among the less volatile. In fact, Boz, Durdu, and Li (2009) report that the ratio between wages and output standard deviations is on average 2 for emerging markets and .84 for developed countries. In Chile, this ratio is .5 when CPI is used as a deflator while is around 2 when wages are deflated by the price of imports. Contemporaneous correlation of wages with output is around .20. Boz, Durdu, and Li (2009) also show that low correlation between real wages and output is also common among developed countries (being even negative in some of them), but that it is less common in emerging markets where correlation between this two variables are typically above .20.

Labor markets transitions hazard rates: We use micro level data from Chilean unemployment survey to compute labor market gross flows.[6] The data is available for the period 1993 - 2009. We consider three possible labor status: employment (E), unemployment (U) and out of the labor force (I). We improve over previous measure of hazard rates of Chilean labor markets by correcting the series for the so called "time - aggregation - bias" following Shimer (2007) methodology. Table 2 shows the business cycle behavior of these hazard rates.

Hazard rates are very volatile, with standard deviations that range from 4.6 to 8.6 times the volatility of labor productivity. Starting with the intensity of movements within the labor force - E to U and U to E -, table 2 shows that the transition from employment to unemployment is negatively correlated with labor productivity (-.29) and output (-.54), but not contemporaneously correlated with terms of trade. However, the separation or destruction rate (the flow from E to U) is negatively correlated with lags of both series of international prices, meaning that changes in terms of trade tend to precede movements in the separation rate. On the other hand, the transition rate from unemployment to employment, also called the job finding rate, is positively and highly correlated with the contemporaneous labor productivity, output and positively correlated with mining terms of trade. Its correlation with non - mining terms of trade is positive, but weak.

Hazard rates for transitions out of labor force (E to I and U to I) are positive correlated (either contemporaneously or with lags of) productivity, output and both measures of terms of trade. As shown in figures 4 and 5 correlations tend to be higher in the case of mining terms of trade. Transitions into the labor force behave very differently. The transition from out - of - the - labor force to unemployment is almost not correlated with productivity, output, and the other variables in the table with the exception of the negative correlation with non mining terms (see also figures 4 and 5). The transition rate from out of the labor force to employment behaves very similar to the hazard rate for the transition from unemployment to employment. This is not surprising since labor force status data is collected quarterly and so it is possible that a flow going from I to E is hiding a combine flow from I to U and from U to E. This possibility could be relevant even though we corrected for time aggregation bias.

[6]See Jones and Naudon (2009) for a description of how these data was constructed.

To further explore the source behind unemployment variations we decompose the variance of unemployment rate deviation from its trend into the incidence related with each of the six gross flows described above. We follow Fujita and Ramey (2009) in using a log - Taylor approximation of the unemployment rate. Results are presented in table 3 and show that around 81% of the cyclical variation of the unemployment rate is related with flows within the labor force (flows form E to U and from U to E). Based on this evidence we will concentrate on flows within the labor force to explain the fluctuations in the unemployment rate.

2.2 The observed effects of terms of trade

In this subsection we document the effects of changes in terms of trade on several aspects of the Chilean labor markets. Again we differentiated between the effect of changes in the price of mining and non - mining exports prices. Our empirical model is semi-structural vector autoregressive (SVAR) that has the following form:

$$A \begin{bmatrix} \widehat{tot}_t \\ \widehat{X}_t \\ \widehat{z}_t \end{bmatrix} = B(L) \begin{bmatrix} \widehat{tot}_{t-1} \\ \widehat{X}_{t-1} \\ \widehat{z}_{t-1} \end{bmatrix} + \varepsilon_t,$$

where $\widehat{tot}_t$ denotes the terms of trade that can be either the mining terms of trade (P_t^{MIN}) or the non - mining terms of trade (P_t^X); $X_t := \left\{ r_t^*, y_t^*, P_t^N, \frac{Y_t^N}{L_t^N}, \frac{Y_t^X}{L_t^X}, GOV_t \right\}$ is the set of control variables that includes the relevant foreign real interest rate - which is computed by adding the spread of Chilean government bonds to the three month libo rate in dollars and subtracted the United States expected inflation -, foreign output, the price of non tradable goods relative to the price of imports, the average labor productivity in both the non tradable and the exportable sector, and real government expenditures. The role of foreign variables as controls in the SVAR is used to identify innovations in the terms of trade that are beyond the international business cycle. Also, the presence of other domestic variables in X obeys to the purpose of capturing the conventional channels through which terms trade shocks affect the sectoral equilibrium between tradable and non tradable production. When we analyze the effects of the non - mining terms of trade we also control for the mining terms of trade. Finally, the variable $z_t \in \left\{ N_t^N, N_t^X, UR_t, VAC_t, SEP_t, FIN_t \right\}$ is one of the labor markets variable of interest: employment in both sectors relative to working age population (N_t^N y N_t^X), the unemployment rate (UR_t), the number of vacancies relative to working age population (VAC_t), the separation rate (SEP_t) and the finding rate (FIN_t). We include the variables in the vector z one by one. The variable $\hat{g}_t$ denotes that g_t is expressed as log deviation from a Hodrick-Prescott trend with a lambda factor equal to 1600. All variables are seasonally adjusted using X12 filter. The vector ε_t includes the set of non correlated and mean zero errors, with a covariance matrix equal to Σ_ε. Finally, A is a matrix and $B(L) := B_0 + B_1 L + B_2 L^2 ...$ is a lag polynomial where L is the lag operator and B_i are matrices.

Since Chile is an small open economy all international variables, including both series of terms of trade, are taken as completely exogenous. Therefore, we set to zero the corresponding coefficients in matrices B_i and in the covariance matrix. In the estimation we allow for contemporaneous influences of both r^* and y^*. Since we are interested in the effects of P_t^{MIN} and P_t^X these restrictions are enough for identification purposes.

Therefore we estimate 12 (6 variables and 2 shocks) SVAR. We use quarterly data from 1989:1 to 2009:4 for N_t^N, N_t^X UR_t and VAC_t; and data from 1993:2 to 2009:4 for SEP_t and FIN_t . The selection of the period is determinate only by data availability. We also run the same SVAR using quarterly data starting in 1986:1 for those variables that have larger span of data and the impulse responses for the other variables are very similar in both shape and magnitude. Because of data limitation we selected the specification with less lags, but at the same time we check that is not sensible to the introduction of more lags. This turns out to be a specification with two lags.

Figure 6 displays the impulse response function of non tradable employment, exportable employment, the price of non tradable, the unemployment rate, vacancies, destruction rate and finding rate to a one standard deviation innovation in the price of non - mining exports relative to the price of imports. The grey area shows the 90% confidence band computed using a non parametric bootstrap. Starting with employment, the response of this variable in the non tradable sector is negative, although not significant. On the other hand, the response of employment in the exportable sector is positive and larger than in the non tradable sector. However, since employment in the exportable sector is about one third of the employment in the non tradable sector, the unemployment rate increases, as shown in the same figure, although the effect is not significant. The number of vacancies increases at the beginning to decrease afterwards. Both separation and finding rates decreases.

Figure 7 displays the impulse response function of same variables in figure 6, but to a one standard deviation innovation in the price of mining exports. Again, the grey area shows the 90% confidence band computed using a non parametric bootstrap. Contrary to the case of non - mining terms of trade, in the case of mining terms of trade movements in labor variables are very significant. In particular, employment increases in both sectors. The unemployment rate goes down driven by both: a decrease in the destruction rate and an increase in the finding rate. Consistently, vacancies increase significantly with better mining terms of trade.

2.3 Summary

- Unemployment rate and vacancies are volatile, highly correlated with the labor productivity, output and mining terms of trade. However there is no a clear correlation with non - mining terms of trade.

- Wages are less volatile than unemployment rate and vacancies; not highly correlated with labor productivity and output, but positively correlated with terms of trade.

- Separation rate is negatively correlated with productivity and uncorrelated with contemporaneous terms of trade, but negatively correlated with lags of both international prices. It accounts for around 50% of unemployment variance.

- Job finding rate is highly correlated with productivity and output. It is also positively correlated with mining terms of trade. It accounts for around 30% of unemployment variance.

- Transitions rates out and into the labor force, with the exception of the hazard rate of transiting from out - of - the - labor - force to unemployment, are positive correlated with labor productivity and output, and have a mixed relation with terms of trade. All these four transition together accounts for less than 20% of the variance of unemployment rate.

- Estimated impulse responses show that unemployment rate increases and vacancies decrease (after some quarters) with better non - mining export prices, although the effects are small.

- Regarding the effects of mining terms of trade, the impulse responses show that the unemployment rate decrease significantly with better mining prices. This reduction in unemployment is driven by an increase in vacancies, a reduction in the separation rate and the corresponding increase in the job finding rate.

3 The model

The model is build on the search friction - real business cycle model in Shimer (2010a) and extended to an small open multi - sector economy setting. In particular, we consider a small open economy populated by a mass one of identical infinite lived individuals. All individuals live in a representative household that, following Andolfatto (1996) and Merz (1995), maximizes the equal-weighted sum of its members' utility. There are four types of goods in our economy: an exportable (X), an importable (M), a non-tradable (N) and commodity good (Co), which in the case of Chile is mining production. Since our economy is small and open, exportable and the importable goods are internationally traded and their prices are taken as exogenous. The commodity good production is an endowment that is completely exported abroad at a exogenous prices. Households consume the exportable, the importable and the non-tradable goods. Regarding production location, we assume that the importable good is produced abroad only, while the other three goods are produced only locally. Exportable and non-tradable goods are produced using capital and labor. In each of these two sectors, there is a representative firm that owns capital and hire workers. In turn, the investment is new capital is a combination of importable and non-tradable goods.

3.1 Labor Markets Frictions

The labor market decisions are structured in the following manner. At the beginning of every period household's members are either working or searching for a job (i.e. there is neither labor force participation decision nor on the job searching). In any period, agents who are searching for a job can do it exclusively either in sector X or N, but they are not allowed to search for jobs simultaneously in both sectors. After one period, agents who are still looking for jobs can eventually change the sector where they are searching. This assumption imposes a transitory segmentation of the labor market, which limits degree of labor reallocation, but it is less extreme and more realistic than a permanent sectoral labor market separation.

There are standard Diamond - Mortensen - Pissarides search frictions in both sectoral labor markets. Our framework builds on Shimer (2010a) by assuming that each period, every firm divides its total workers between production and recruiting activities. Let n^j, v^j and u^j be the mass of employees in sector j, the portion of employees in search activities in sector j and the mass of households searching for job in sector j, respectively. Defining the labor market tightness in sector j by $\theta^j = \dfrac{v^j n^j}{u^j}$, we assume that the number of matches in every period and sector j is given by,

$$m\left(u^j, v^j n^j\right) = A\left(v^j n^j\right)^{\gamma}\left(u^j\right)^{1-\gamma}, \tag{1}$$

where A is a parameter regulating the search efficiency, and γ is a parameter regulating the elasticity of the probability of finding a job in sector j with respect to market tightness in that sector. This expression is known as the matching function. Note that, assuming random matching, the probability of finding a job in sector j is given by $\pi^j = \frac{m\left(u^j, v^j n^j\right)}{u^j} = A\left(\theta^j\right)^{\gamma}$. Similarly, the probability that a firm in sector j finds a new worker is given by $q^j = \frac{m\left(u^j, v^j n^j\right)}{v^j n^j} = A\left(\theta^j\right)^{\gamma-1}$. The assumption of a constant return to scale technology for the matching function is common in the literature (see, for example, Pissarides (2000)).

Note that π^j is the probability of finding a job in sector j "conditional on looking for a job in this sector" (i.e. conditional in being part of u^j). Associated to this probability would be the flow of being unemployed in sector j and find a job sector j in the next period. Unfortunately, we do not observed this labor flow in the data. Thus, we require to define the probability of moving from the total unemployment to employment in sector j. In our framework will consider that all household's members are identical, which implies that unemployed agents can be randomly assigned to search for a job in any of the two sectors. Thus, without loss of generality, we can define the probability of moving from unemployment to employment in sector j as $\pi^j \cdot \frac{u^j}{u}$, and the aggregate probability of getting a job as $\pi^N \cdot \frac{u^N}{u} + \pi^X \cdot \frac{u^X}{u}$. Jobs in sector j are exogenously terminated at a rate $1 - \rho^j$.[7] However, one can consider a destruction rate of employment in each sector as a given function of other variables. Of course, this possibility would be a reduce form of structural relationships between employment separation rate and underlaying fundamentals.[8]

3.2 Households

Having described the basic structure of the economy, we now turn to the description of households' behavior. Households' problem is triple. First, they have to choose how much to consume of each type of good. Second, they have to choose how many members of the family are to be searching for a job in each sector, and finally they face the traditional intertemporal saving problem. The first problem is essentially static, while the other two are dynamics.

Starting with the first problem. let c_t^i with $i = N, X, M$ be the consumption of each type of goods in period t, and assume that households instantaneous utility is given by,

$$U\left(c_t, n_t^N + n_t^X\right) = \frac{c_t^{1-\sigma}\left(1 + (\sigma - 1)\, b\left(n_t^N + n_t^X\right)\right)^{\sigma} - 1}{1-\sigma}, \tag{2}$$

with

$$c_t = \left[\varphi^{\frac{1}{\omega}}\left(c_t^N\right)^{\frac{\omega-1}{\omega}} + (1-\varphi)^{\frac{1}{\omega}}\left(c_t^T\right)^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}},\ c_t^T = \left(\frac{c_t^X}{\chi}\right)^{\chi}\left(\frac{c_t^M}{1-\chi}\right)^{1-\chi}. \tag{3}$$

n_t^X and n_t^N are the proportion of household members working in sector X and N, respectively, and c_t^T is the consumption of tradable goods. σ is the inverse of the intertemporal elasticity of substitution and $b > 0$ captures the disutility of working. When $\sigma \neq 1$, this parameter measures the degree of complementarity between consumption and employment. Note that, as emphasized by Shimer (2010b), if $\sigma > 1$, employed household's member will consume more

[7] The employment exit probability is usually treated as an exogenous variable in the search friction models.
[8] In the present version of the paper, we leave for future research this possibility.

than their unemployed relatives.[9] It is also important to note that assuming perfect risk sharing between household's members, as in Andolfatto (1996) and Merz (1995), preferences in equation (2) could be derive from standard preferences with indivisible labor. Finally, $\varphi \in (0,1)$ and $\chi \in (0,1)$ determinate the share of non-tradable in total consumption and the share of exportable in tradable consumption, while $\omega > 0$ is the consumption elasticity of substitution between tradable and non-tradable goods.

Assuming that the price of imports is numéraire, $P_t^M = 1$, the composition of the consumption basket is similar to Mendoza (1995) and implies the following demands for each type of good:

$$\begin{aligned} c_t^N &= \varphi \left(\frac{P_t}{P_t^N}\right)^{\omega} c_t, \qquad c_t^T = (1-\varphi)\left(\frac{P_t}{P_t^T}\right)^{\omega} c_t, \\ c_t^X &= \chi \left(\frac{P_t^T}{P_t^X}\right) c_t^T, \qquad c_t^M = (1-\chi)\left(P_t^T\right) c_t^T, \end{aligned} \tag{4}$$

where

$$P_t^T = \left(P_t^X\right)^{\chi}, \quad \text{and} \quad P_t = \left[\varphi \left(P_t^N\right)^{1-\omega} + (1-\varphi)\left(P_t^T\right)^{1-\omega}\right]^{\frac{1}{1-\omega}}. \tag{5}$$

Now we describe the two intertemporal problems facing by the households. Households must decide how much to save in both local and foreign assets, and how many family members are going to be searching for a job in each sector. The problem is similar to Shimer (2010a), and so we keep the details at a minimum in the present document. More formally, we will write the dynamic problem of households in a recursive manner. To do so, we denote by $\mathcal{S}$ the list of state variable of the decision problem. In our model, $\mathcal{S} := \left\{a, a^*, n^X, n^N\right\}$, where a and a^* are the domestic and foreign assets, respectively. We will define $H(\mathcal{S})$ as the expected present value of household's utility when the current state is $\mathcal{S}$. To express $H(\mathcal{S})$ in a recursive form, we will denote by $\mathbf{E}[\cdot]$ as the expectation operator conditional in the information in the current period and g' and g_{-1} as the value of the variable g in the next and past period, respectively. Thus, households solve the following recursive problem,

$$H(\mathcal{S}) = \max_{c, u_N, u_X, a\prime, a^{*\prime}} \left\{U(c,n) + \beta \mathbf{E}\left[H(\mathcal{S}')\right]\right\}, \tag{6}$$

subject to

$$Pc + Pa' + a^{*\prime} = w^N n^N + w^X n^X + (1 + r_{-1}) Pa + \left(1 + r_{-1}^*\right) a^* + \Omega, \tag{7}$$

$$1 = u^N + u^T + n^N + n^X, \tag{8}$$

$$n = n^N + n^X \tag{9}$$

$$n^{N\prime} = \rho^N n^N + \pi^N u^N, \tag{10}$$

[9] Despite of this, in the calibrated model we consider a standard logarithmic case, where $\sigma = 1$.

$$n^{X\prime} = \rho^X n^X + \pi^X u^X. \tag{11}$$

Equation (7) is the standard budget constraint expressed in terms of importable. This expression states that, in each period, assets and consumption purchases are equal to household's income. The latter is the sum of labor income and the value of assets and their return. w^X and w^N are the wage rates paid for working in sector X and N, respectively. Note that due to the transitory sectoral labor segmentation wages could be different across sectors. Ω are the profits of firms that are owned by households and r and $r^\star$ and the interest rate paid for domestic and foreign asset holdings. The equation (8) states that people are either working or searching for a job in one of the two sectors, so labor force participation is constant in our model. We assume this formulation since, as the evidence presented above suggested, even though flow between labor force and out of labor force status are large, at business cycle frequency their importance is small. Restriction (9) is just a definition for total employment. The last two restrictions ((10) and (11)) determinate the evolution of employment in each sector. As we mentioned above, in our formulation household's members are allow to search only in one sector per period. In each sector $j = N, X$, a fraction π^j of unemployed households's members in sector j find a job each period and a fraction ρ^j of employed households's members in sector j keeps working in the next period. Note that since the number of workers in each sector is a predeterminate variable, so is the mass of unemployed people. The problem of the household is to decide which share of the later will be searching for a job in each sector.

From assets first order and envelope conditions we get the standard Euler equations:

$$U_c(c,n) = \beta \mathbf{E}\left[(1+r) U_c(c',n')\right], \tag{12}$$

$$U_c(c,n) = \beta \mathbf{E}\left[(1+r^*) \frac{P U_c(c',n')}{P'}\right] \tag{13}$$

where $U_c(c,n)$ is the partial derivative of utility function with respect to consumption. Note that $\Lambda = \frac{P}{P'}\frac{U_c(c',n')}{U_c(c,n)}$ is the stochastic discount factor in terms of the importable goods. Since households are the owners of the firms, Λ is also the relevant discount factor for firm's profit flows.

The first order condition for sectoral unemployment is given by,

$$-U_n(c,n) + \pi^j \beta \mathbf{E}\left[H_{n^j}(\mathcal{S}')\right] = 0, \tag{14}$$

where $U_n(c,n)$ is the partial derivative of the utility function with respect to total employment, while H_{n^j} is the partial derivative of function H with respect to n^j. This equation states that the expected discounted marginal value of having one extra member of the family working in sector j in the next period should be equal to the disutility of working. Combining (14) for each sector it is possible to get the following indifference condition, that states that even though wages could be different across sectors, and so the marginal benefits of having an extra worker there, after correcting by the probability of getting a job household must be indifferent between working in each sector,

$$\pi^N \mathbf{E}\left[H_{n^N}\left(\mathcal{S}'\right)\right] = \pi^X \mathbf{E}\left[H_{n^X}\left(\mathcal{S}'\right)\right], \tag{15}$$

Finally, the envelope condition for the level of employment in sector j is given by

$$H_{n^j}\left(\mathcal{S}\right) = U_n(c,n) + U_c(c,n)\frac{w^j}{P} + (\rho^j - \pi^j)\beta \mathbf{E}\left[H_{n^j}\left(\mathcal{S}'\right)\right] \tag{16}$$

where $U_n(c,n)$ is the partial derivative of the utility function with respect to total employment.

3.3 Firms

In each sector production takes place in a representative firm that combines capital and workers using a constant return to scale production function $f^j(.)$. Production also depends on a time varying productivity level. More formally, let y_t^j be the production in sector $j = N, X$, then

$$y_t^j = \exp\left(z_t^j\right) f^j\left(k_t^j, n_t^j\left(1 - v_t^j\right)\right) = \exp\left(z_t^j\right)\left(k_t^j\right)^{\alpha^j}\left(n_t^j\left(1 - v_t^j\right)\right)^{1-\alpha^j}, \tag{17}$$

where $\left(z_t^j\right)$, k_t^j, n_t^j and v_t^j are, respectively, total factor productivity in sector j, capital in sector j, total employment in sector j and the fraction of employees in sector j in recruitment activities. The second equality establishes that production has a Cobb-Douglas technology where α^j determines the share of capital in sector j.

Firms in both sectors own capital (k^X and k^N) and decide on the fraction of recruiters (v^X and v^N)and hire workers ($n^{X\prime}$ and $n^{N\prime}$) so that to maximize the expected present value of profits. In order to write the problem recursively we will define $F^j(n^j, k^j)$ as the expected present value of profits of the representative firm in sector j that starts the period with amount k^j of capital and with a mass n^j of workers. Then the firm solves the following problem:

$$F^j\left(n^j, k^j\right) = \max_{k^{j\prime}, v^j}\left\{P^j y^j - w^j n^j - P^I i^j + \beta E\left[\Lambda F^j\left(n^{j\prime}, k^{j\prime}\right)\right]\right\}, \tag{18}$$

subject to

$$y_j = \exp(z_j) f^j\left(k_j, n_j\left(1 - v^j\right)\right), \tag{19}$$

$$n^{j\prime} = n^j\left(\rho^j + q^j v^j\right), \tag{20}$$

$$k^{j\prime} = (1 - \delta)\, k^j + \mu\left(\frac{i^j}{k^j}\right) k^j. \tag{21}$$

Thus, a firm selects next period capital, current recruiting effort and investment in new capital in order to maximize the present value of the flow of profits. This expected present value of profits can be written recursively as the sum of to the value of production minus the labor costs and the cost of new capital, plus continuation value of the firm properly discounted using the stochastic discount factor, Λ. The equation (20) characterizes the evolution of firm employment, which is determinate by the mass of workers that keep their jobs $n^j \rho^j$ plus the mass of new hirings $v^j n^j q^j$. On the other hand, equation (21) states the evolution of capital in the next period as the sum of non depreciated capital plus investment net of adjustment costs.[10]

Besides the evolution of employment and capital, the optimal behavior of firms is described by the following equations. First, capital must satisfy an Euler condition for the return to capital. To obtain this expression let y_{k^j} represents the marginal product of capital in industry j. Thus, the equality between the current value of one unit capital and the expected marginal benefits of one unit of capital next period can be written as:

$$\nu^j = \beta E \left[\Lambda \left(P^{j\prime} y'_{k^j} + \nu^{j\prime} \left(1 - \delta + \mu \left(\frac{i^{j\prime}}{k^{j\prime}} \right) - \mu' \left(\frac{i^{j\prime}}{k^{j\prime}} \right) \frac{i^{j\prime}}{k^{j\prime}} \right) \right) \right]. \tag{22}$$

where ν^j is shadow price of capital in sector j and $\mu'(\cdot)$ is the derivative of adjustment cost with respect to investment-to-capital ratio. The Tobin's Q condition for the demand for investment is characterized by:

$$\mu' \left(\frac{i^j}{k^j} \right) \frac{\nu^j}{P^I} = 1 \tag{23}$$

Finally, la determination of the fraction of employees in recruitment activities is also an intertemporal decision since affect the level of employment in the next period. Defining y_{n^j} as the marginal product of labor in sector j, then using the first order condition for v^j and the envelope condition for labor in sector j we obtain

$$\frac{P^j y_{n^j}}{q^j} = \beta E \left[\Lambda \left(P^{j\prime} y'_{n^j} \left(1 + \frac{\rho^{j\prime}}{q^{j\prime}} \right) - w^{j\prime} \right) \right]. \tag{24}$$

This equation simply state that the fraction v^j is chosen such that future discounted expected flows that generates equals current value of a recruiter. The future flow is equal to the production value of a worker plus the fact that the firm will need $\frac{\rho_j'}{q_j'}$ less recruiters to keep constant the level of employment, minus the wage of the new worker. The opportunity cost of finding this worker is equal to $P^j y_{n^j}$, i.e., the value of the output not produce by the recruiters, times $\frac{1}{q^j}$ which is equal to the number of recruiters needed to find a new worker. Note that by the law of large numbers, given q^j, there is no uncertainty about how many workers a recruiter could attract in each period.

[10] The presence of an adjustment cost in small open economy is required to obtain a volatility of investment relative to GDP similar to that observed in the data.

3.4 Investment basket

New capital in both sectors are obtained as a combination of importable and non-tradable goods. In particular, consistently with Bems (2008), we assume that new investment goods are produced according to the following production function,

$$i^X + i^N = i = \left(\frac{ci^N}{\varepsilon}\right)^{\varepsilon} \left(\frac{ci^M}{1-\varepsilon}\right)^{1-\varepsilon}, \tag{25}$$

where ci^N and ci^M are the amount of non tradable and importable goods used in total investment $i = i^X + i^N$. $\varepsilon \in (0, 1)$ is a parameter that determines the share of non-tradable expenditures in the aggregate investment basket. Under perfect competition in this sector, the investment basket will minimize its costs, which generates the demands for non-tradable and importable goods for investment:

$$ci^N = \varepsilon \frac{P^I}{P^N} i, \tag{26}$$

$$ci^M = (1-\varepsilon) P^I i, \tag{27}$$

where the price of the investment goods is given by,

$$P^I = \left(P^N\right)^{\varepsilon}. \tag{28}$$

It is a standard assumption in a multi-sector open economy model to consider that all capital is imported (i.e. $\varepsilon = 0$). However, as it has been shown by Bems (2008), this assumption is far from innocuous, since the dynamic of the model is strongly affected by the elasticity of investment to non-tradable prices. For that reason, we include non-tradable goods in the basket as more realistic assumption which, in turn, capture the role of building in total investment.

3.5 Wages

In the presence of search frictions there is a surplus when an unemployed workers finds a firm searching for a new worker. This surplus must be divided between the firm and the worker. Clearly, this division could be done in many different ways. We follow the literature and assume that the surplus is divided between firms and workers as the results of a Nash Bargaining. Let η represents the bargaining power of the workers, then the Nash bargaining assumption implies that in each sector j the following condition is satisfied

$$\eta F_n^j \left(n^j, k\right) \frac{U_c\left(c, n\right)}{P} = (1-\eta) H_{n^j}\left(\mathcal{S}\right), \tag{29}$$

where $F_{n^j}^j(n^j,k)$ is the marginal value of an additional worker for a firm in sector j and $H_{n^j}(\mathcal{S})$ is the marginal value of an additional sector j worker for households. Using first order and envelope conditions from households and firms, it is possible to obtain the following equation

$$w^j = \eta P^j y_n^j \left(1+\theta^j\right) - (1-\eta)\frac{U_n(c,n)}{U_c(c,n)}P, \tag{30}$$

that indicates that the wage in sector j, w^j, is a weighted average of the benefits obtained by the firm, $P^j y_n^j (1+\theta^j)$, and the marginal rate of substitution between labor and consumption in terms of importable, $-\frac{U_n(c,n)}{U_c(c,n)}P$.

When simulating the effects of foreign variables we follow Shimer (2010a), assuming an additional calibration where a degree of wage rigidity is introduced.[11] In this case, the actual wage, $\widetilde{w}^j$, in sector j would differ from its target value specified in equation (30). In particular, we assume that the actual wage is determinate by the following equation,

$$\widetilde{w}^j = (1-\phi)\,\widetilde{w}_{-1}^j + \phi w^j \tag{31}$$

In this case the rigidity is imposed in terms of importable goods and parameter ϕ control the degree of rigidity. Alternatively, we can consider that wage rigidity is expressed in terms of the consumption price:

$$\frac{\widetilde{w}^j}{P} = (1-\phi)\frac{\widetilde{w}_{-1}^j}{P_{-1}} + \phi\frac{w^j}{P} \tag{32}$$

Below, we will consider both type of wage rigidities when obtaining the dynamics of the model.

3.6 Aggregate equilibrium

We finish the description of our model economy specifying the aggregate equilibrium conditions. Note that we have already stated that production factor markets are in equilibrium. Equilibrium in non tradable sector implies that

$$y^N = c^N + ci^N, \tag{33}$$

The balance of payments implies that the current account should be equal to the change in international net investment position, that is,

$$B' - B = r_{-1}^* B + P^X\left(y^X - c^X\right) - P^M c^M - ci_M + P^{Co} y^{Co}, \tag{34}$$

[11] The importance of rigid wages for explaining labor markets dynamics in a closed economy setting has been emphasized by Shimer (2005) and Hall (2005).

where P^{Co} and y^{Co} are the price and endowment of commodity. Since households are the only agents that do financial transactions with the rest of the world: $B = a^*$.

Finally, it is important to specify other aggregate variables. Total real GDP can be defined as $y = y^X + y^N + y^{Co}$, total unemployment as $u = u^N + u^N$ and total fraction of recruiters (a proxy of job vacancies) as $v = \frac{n^N}{n}v^N + \frac{n^X}{n}v^X$. As we mentioned above, the aggregate finding rate can be expressed as $\pi = \pi^N \frac{u^N}{u} + \pi^X \frac{u^X}{u}$ and we can define the aggregate employment separation rate as $d = (1-\rho^N)\frac{n^N}{n} + (1-\rho^X)\frac{n^X}{n}$.

3.7 Exogenous processes

We have described eight exogenous variables in the model economy: foreign interest rate, commodity or mining prices, exportable or non-mining price, commodity production, sectoral productivity and sectoral destruction rates. Given that we exclusively focuss in this work in the responses of foreign shocks, we will only describe the stochastic process of terms of terms fluctuations and the role of the external interest rate.

International prices: Let P^M and P^X denotes the price of importable and exportable goods respectively. Given the small size of the economy both prices are taken as exogenous. We take the price of importable as numéraire, so we set $P^M = 1$ and the price of the exportable good (relative to the imported goods) follows the following stochastic process:

$$\log P_t^X = (1-\rho_{P^X}) \log \overline{P}^X + \rho_{P^X} \log P_{t-1}^X + \varepsilon_{P^X,t}, \tag{35}$$

with $E\left[\varepsilon_{P^X,t}\right] = 0$ and $E\left[\left(\varepsilon_{P^X,t}\right)^2\right] = \sigma^2_{P^X}$. Since P^M is equal to one, non-mining terms of trade are equal to the price of exportable, P^X . $\overline{P}^X$ is the steady state level of the non-mining terms of trade and $\sigma^2_{P^X}$ is the variance of its innovations in (35). We assume that $\rho_{P^X} \in (0,1)$ and so terms of trade are covariance stationary. Similarly, we consider that the price of mining exported (relative to imported goods), P^{Co}, follows stochastic process characterized by:

$$\log P_t^{Co} = (1-\rho_{P^Co}) \log \overline{P}^{Co} + \rho_{P^Co} \log P_{t-1}^{Co} + \varepsilon_{P^Co,t}. \tag{36}$$

where $\rho_{P^Co} \in (0,1)$, $E\left[\varepsilon_{P^Co,t}\right] = 0$ and $E\left[\left(\varepsilon_{P^Co,t}\right)^2\right] = \sigma^2_{P^Co}$. This price can be interpreted as mining terms of trade.

Foreign interest rate: Households could trade international risk free bonds denominated in units of importable good that pays an interest rate equals to $\overline{r}^*$. Our economy is not perfectly integrated with the rest of the world and so there is an spread between the interest rate at which local and foreign people could get debt in international markets. More specifically, we assume that the relevant foreign interest rate faced for the economy contains a premium, which is a function of its net foreign asset position:

$$r_t^* = \overline{r}^* + \psi \left[\exp\left(B_t - \overline{B}\right) - 1\right], \tag{37}$$

where B represents the economy net international asset position and $\overline{B}$ is its steady state value. This upward sloping supply of funds is also needed in order to have well defined dynamics around its unique steady state.[12]

4 Calibration

Time period is a month.[13] This implies that parameters that have an implied rate that is intertemporal such as depreciation rate, subjective discount factor and autoregressive coefficients for exogenous shocks have to be converted from a quarterly to a monthly value. Parameters for the based calibration are presented in table 4. Variables with a "$\overline{\cdot}$" denote the steady state value of that variable. We normalize prices and wage relative to the deflator of imports at one. Below we explain how we choose most of the parameters values based on data for Chile.

We construct quarterly statistics to be consistent with the data presented in section 2. In all cases, the exportable includes agriculture and industrial sectors, and the non-tradable sector includes all other sectors but mining. Y^{Co} corresponds to the total production of the mining sector.

Household's parameters: We consider $\sigma = 1$, which implies a case with logarithmic utility over consumption and separability between consumption and labor. The subjective discount factor is set at 0.9967, which implies a steady state interest rate of 4% in annual basis. The average unemployment rate in the data from 1986 to 2009 is around 8.5%. We use that value for the steady state level of the unemployment rate. This requires that the parameter of disutility of labor is set at $b = 0.4757$. The share of non-tradable goods in the

[12]This assumption works also as a closing device in a small open economy setting. See Schmitt-Grohe and Uribe (2003) for alternative way to close dynamics in small open economy models.

[13]The main advantage of using monthly frequency is because we can generate labor flows in quarterly frequency in spite of not having definite them in a monthly frequency. An example of this is the flow between tradable and non tradable employment. Other reason is that monthly frequency is standard in the literature and allows us comparability of parameters governing the matching frictions and technologies.

consumption basket is close 50% while within the tradable basket consumption of exportable is also near 50%.

Firms' parameters: Since we use Cobb Douglas production functions in both sector, labor shares $(1-\alpha^i)$ for sectors $i = X, N$ are computed using the most recent input-output matrix of Chile's national accounts (using previous does not change the results). We follow Cooley, Hansen, and Prescott (1995) by assuming that the proportion of ambiguous capital income to ambiguous income is the same as the proportion of unambiguous capital income to unambiguous income. And follow Gollin (2002) by adjusting for informality. This calculation implies that exportable is relatively intensive in capital while non-tradable is relatively intensive in labor. In particular, close to one third is the labor share in the non-mining sector (sector X) and the capital share in the non-tradable sector. We assume a depreciation rate of 6% in annual basis similar to other studies for Chile (see for example Medina and Soto (2007)).

Labor market parameters: Sectoral employment data show that 65% of the total employment is in the non-tradable sector. The value of $\bar{\theta}$ is calibrated as follows. We start using the fact that ρ^j is the same in both sectors, implying that θ^j is the same for both the X and the N sectors at the steady state. Therefore, $\pi = \pi^X = \pi^N$ at the steady state is just the finding rate in the whole economy, which in the case of Chile is equal to 0.2355 (See Jones and Naudon (2009)). This property is important because u^X and u^N are not observable, making impossible to compute the π^i from the data. However, as in Shimer (2010a), we use the information in Hagedorn and Manovskii (2008) and Silva and Toledo (2009) that indicate that recruiting uses approximately 4% of one worker's quarterly wage, that means that on average $q^j = 25$ (a worker attract $1/.04 = 25$ workers in a quarter). On average, the finding rate and the rate at which recruiters hire a new worker are

$$\bar{\pi} = A\bar{\theta}^{1-\gamma} \rightarrow \pi^{\gamma} = A^{\gamma}\bar{\theta}^{\gamma(1-\gamma)}$$

$$\bar{q} = A\bar{\theta}^{-\gamma} \rightarrow \bar{q}^{1-\gamma} = A^{1-\gamma}\bar{\theta}^{-\gamma(1-\gamma)}$$

then

$$A = \bar{\pi}^{\gamma}\bar{q}^{1-\gamma}$$

with $\gamma = .5$ we get $A = 1.4009$. Also note that

$$\bar{\theta} = \frac{p}{q} = \frac{0.2355}{25/3} = 0.02826$$

Other parameters: We consider that the investment basket is a little more intense in tradable goods than the consumption basket. Thus, we assume that $\varepsilon = 0.40$, i.e., investment has a 40% of its basket in non-tradable goods. Adjustment cost has a functional form such that $\mu(\delta) = \delta$, $\mu'(\delta) = 1$ and $\mu''(\delta) = -\zeta$. We calibrate the value of ζ in order to replicate the relative standard deviation of investment to total GDP observed in Chile (around 4). Trade balance is assumed equal to zero and therefore the net asset position of the economy at the long-run, $\overline{B}$ is also zero. From national account total mining production (mainly copper) explain around 10% of total GDP. We calibrate the ψ in low value as Schmitt-Grohe and Uribe (2003) to reduce the effect of this closing device for a small open economy model.

Exogenous processes: Parameters describing the stochastic process in the model were obtained by OLS estimation of the corresponding HP filtered data. For terms of trades we uses national accounts deflators. P^X is the ratio between export deflator without mining and import deflator. P^{Co} is the ratio between mining deflator and import deflator. With this we obtain that international prices are quite persistent with autoregressive coefficients in a range between 0.80 and 0.95 (monthly frequency). Importantly, the size and persistence of terms of trade shocks are equal to the ones estimated in section 2.

Alternative calibrations: As we mentioned above we will explore the model implications of wage rigidity in the responses of labor market variables after foreign shocks. In doing so, we assume that two cases. One case will assume that the wage inertia is expressed in terms of importable as in (31). The other case will consider that wage in terms of consumption price will be rigid as in (32). In both cases, we will use $\phi = 0.90$, which allow to illustrate the role and type of wage rigidity in propagating the terms of trade shocks. Also, we consider other calibration where the economy is assumed that cannot adjust its foreign position and all periods has to run trade balance equal to zero. This situation will magnify the income effect of terms of trade shocks and can help to understand the role of this channel in affecting labor market variables in Chile.

5 Model Simulations

In this section we present the responses of the variables in the model economy to the same shocks estimated in section 2. For comparison reasons, we expressed all variables as log deviation of their steady state value even in the cases of variables that already as fraction such as unemployment rate and job finding rate as in section 2. In the first subsection we explore the dynamics in the baseline model comparing with the estimated responses. In the second subsection we analyze how alternative calibrations are able to replicate better the estimated responses to terms of trade shocks.

5.1 Baseline Model

Non-mining terms of trade Figure 8 presents the responses of sectoral variables to an exportable price or non-mining terms of trade shock, P^X. A rise in the non-mining terms of trade induces an increase in the surplus of a job position in the exportable sector (in terms of importables). Due to Nash bargaining, this terms of trade shock translates to both a rise in the in the expected value of profits of firms in the exportable sector and the expected value for households of having members working in sector X. The persistence of the non-mining term of trade increase generates an incentive to hire workers in sector X. Thus, the recruitment effort in the exportable sector (measured by v^X) rises in the short run. In equilibrium, Nash barganing makes that a fraction $\eta = 0.5$ of the rise in the labor productivity (measured in terms of importable) will be absorbed by an increase in the wage paid in the exportable sector. Although there is a transitory segmentation of labor markets across sectors, the rise in the marginal household's benefit of having a worker in sector X pressures the wage in the non-tradable sector up. This increase in the non-tradable wage implies that recruitment efforts in the non-tradable sector falls. A real appreciation, which is reflected in a rise in the price of non-tradable, offsets part of this incentive to reduce hiring in the non-tradable sector.

It is worth noting that the magnitude of the increase in the non-tradable wage is less than the one experienced in the exportable sector. Thus, the search frictions in this model introduces a transitory wedge between the wage paid in the exportable and non-tradable sectors. In a frictionless model there is no wedge across the sectoral wages.[14]

The extra benefits for workers in the exportable sector compared to those in the non-tradable sector also implies an increase in the recruiters or searchers in the exportable sector and a reduction in the non-tradable recruiters or searchers. In our model, the wedge in the wage paid across sectors is also explained by a difference in the probability of getting job in each sector. The labor market tightness (θ^j) and probability of getting a job go up in both sectors, but the chance of finding a job in the non-tradable sector rise more than in the exportable sector. Despite of the fall in the recruitment effort in the non-tradable the reduction in the mass of potential workers searching for a job makes that the labor market tightness rises in the non-tradable sector. In contrast, labor market tightness in the exportable sector goes up by a rise in the recruitment effort, which is partly offset by an

[14] By the assumption of preferences, households are indifferent between working in the exportable and non-tradable sector. Hence, in a frictionless model the wages paid in both sector should be equalized.

increase in the mass of job searchers in the exportable sector.

In equilibrium, the employment in sector non-tradable reduces and the employment in the exportable and non-mining sector increases. Hence, the labor reallocation induced by non-mining terms of trade shocks takes place having several margins that are not usually modelled by international business cycle models. First, the fall in non-tradable employment is reflected by a reduction in the mass of potential workers searching for a non-tradable job and the recruitment efforts of non-tradable firms. Second, the exportable employment is higher because more potential workers decide to look for a exportable job and exportable firms display more recruitment effort.

Figure 9 show the response of additional variables to the same non-mining terms of trade increase. The set of variables are the same that those depicted in section 2 in the estimated SVAR. For comparability we reproduce the estimated responses to the same shock presented in section 2. The estimated responses as in the model induce a fall in the non-tradable employment, a rise in the exportable employment and an increase in the price of non-tradable. Similarly, as in the model, estimation suggests a fall in the labor productivity in the exportable sector and a rise in the labor productivity in the non-tradable sector. However, the baseline model emphasizes a bigger magnitude of labor reallocation across sectors, which occurs in a lower extent in the estimated SVAR. Moreover, the estimated response of the job finding rate is negative while in the model is positive. This last behavior is associated with an estimated increase in the unemployment rate, but no statistical significant. In contrast, the increase in the job finding rate in the model implies a reduction in the unemployment rate.

Mining terms of trade In figure 10 we show the response of sectoral variables to mining terms of trade increase. By simplicity, our model takes mining production as an endowment, assuming that does not use in other factor in production. Hence, the impact of mining terms of trade fluctuations operate through the income effect that exerts over the aggregate demand. The rise in the income is partly consumed and saved by households. The increase in consumption exerts a rise in the demand of all type of goods. Since the price of exportable and importable goods is given, the price of non-tradable goods absorbes the increase in non-tradable consumption. This, in turn, rises the surplus of a job position in the non-tradable sector. Following the same arguments as in the case of non-mining terms of trade, Nash bargaining translates partly in an increase in the non-tradable labor productivity measured in terms of importable and an increase in the non-tradable wage rate. The increased value for a job in non-tradable firms induces a slight increase in the non-tradable recruitment effort on impact. Higher wage rates in the non-tradable sector exert a pressure up in the wage rate in the exportable sector. This last situation reduces the incentive to hire workers in the exportable sector.

The higher perspective of wages in the non-tradable sector induces more potential workers to search for job in the non-tradable sector. This increase is more intense than the recruitment effort by non-tradable firms and the non-tradable labor market tightness fall generating a reduction in the job finding rate in that sector. In the short run, the rise in the exportable wage rate is smaller than the one experienced in the non-tradable sector. The difference is a consequence of distinct chances of getting a job in each sectors. The exportable job finding rate also falls, which is a result of a decrease in the exportable labor market tightness. This reflects a reduction in the recruitment effort in the exportable sector, which is partly offset by a reduction in the searchers for exportable jobs.

As in the case of non-mining terms of trade we compare the response of the baseline model with the estimated responses. This comparison is depicted in figure 11. As it can be inferred from above, model prediction implies a reduction in the exportable employment and a rise in the non-tradable employment after a mining terms of trade improvement. However, the estimated responses show a significant rise in the exportable employment. The point estimates for the increase in the non-tradable employment and price are higher than the one predicted by the model. In opposite direction and statistically significant, the labor productivity at constant prices in the non-tradable sector is estimated to rise in response to a mining terms of trade increase. The fall in the job finding predicted by the model is at odd with the estimated improvement in the job finding rate following a rise in the mining terms of trade. More importantly, the SVAR estimates a significant reduction the job separation rate, a channel that is not considered by the model. Thus, empirical evidence stresses a significant fall in the unemployment rate while in the baseline model, we obtain a slight rise in the unemployment rate.

5.2 Sensitivity Analysis

The results in the last subsection emphasize several dimension where the baseline model is unable to reproduce the estimated responses of labor market variables to terms of trade shocks in Chile. On the one hand, the responses of variables to non-mining terms of trade are plausible qualitatively, implying similar sign of movements. However, the size of the effects are estimated smaller than the deducted by the model. On the other hand, not only the size but also the direction of the responses to mining of terms of trade in the estimated SVAR are conflicted with the model. In order to explore the sensitivity of the model prediction, we compute the responses to the terms of trade shocks under alternative calibrations. Here we will consider how the limitation in the access to the international markets, wage rigidity and movement of job separation rate affect the prediction of the model. We also analyze an extreme case of wage rigidity (namely, $\phi = 0.99$). These simple modifications are not completely structural and their role is to illustrate their merits in reconcile better the model predictions with the estimated responses.

Financial Autarky and Wage Rigidity Figure 12 and 13 show the responses of variable in the baseline model and its variants in response to non-mining and mining terms of trade shocks. We initially considered a case of financial autarky to analysis the relevance of international financial market access. We contemplate two cases of wage rigidity. In one case the wage rigidity is expressed in terms of importable (equation 31 and in the other case is in terms of the consumption price index, CPI (equation 32). In both cases we assume $\phi = 0.90$.

As we saw in the baseline model after a non-mining terms of trade improvement, the wage rates in both sector increase and the non-tradable price increases by less that the actual rise in the non-mining price (X) which, in equilibrium, implies a reallocation force that tends to increase employment in sector X and reduce employment in sector N. However, this labor reallocation across sectors is more muted in the empirical estimation. One possibility to attenuate the reduction in non-tradable labor is to amplify the aggregate income effect of the rise in the non-mining price. One simple way to generate a higher income effect is to consider a economy that has to run trade balance equal to zero each period. We denote this case as financial autarky.[15] We can see that limited international financial integration attenuates the sectoral labor reallocation because generate more aggregate demand for non-tradable that implies an mild rise in employment in sector N. Nevertheless, financial autarky induces a higher real appreciation, which seems excessive compared to the estimated exchange rate movement. Financial autarky also magnifies the increase in the job finding rate and reduction in the unemployment rate, something that looks opposite to the empirical evidence.

Financial autarky is also able to generate a higher real appreciation in the short run in response to a mining terms of trade increase. This helps to induce a rise in non-tradable employment as well, but at the cost to imply a more significant fall in the exportable employment, which is at odd with the estimated response. Non-tradable labor productivity at constant prices increases under financial autarky after a mining terms of trade improvement. The finding rate increases under financial autarky in an order of magnitude similar to the estimated response, which implies a fall in the unemployment rate. However, the estimated

[15]Heathcote and Perri (2002) show that a two-country real business cycle model with financial autarky can generate cross-countries business cycles properties more line with the data. They interpret this result as evidence of the role of limitation in the access to international financial market to explain international business cycles.

size of the reduction in the unemployment after a mining price increase is more than five times bigger.

Figure 12 and 13 have two additional lines, which represent the responses of variable under wage rigidity in terms of importable and in terms of the consumption price index. Despite the reduction on non-tradable labor in the baseline after a non-mining terms of trade, the rise in exportable employment generates an initial reduction of unemployment rate followed by a subsequent rise. The initial reduction is hard to reconcile with the estimated response and the subsequent increase seems smaller in the baseline model than in the data. This later increase in unemployment can be magnified under wage rigidity in terms of importable. As expected wage rigidity in terms of importable reduces the initial increase in wages derived of the rise in non-mining price. However, the same rigidity makes that the subsequent reduction in wages is slower reducing the incentive to hire workers in each sector. This amplification mechanism does not operate when the wage rigidity is in terms of the consumption price.[16] As expected the responses of sectoral employment under both type of wage rigidity are also amplified, which is an undesirable property in comparison with the estimation.

In the case of mining terms of trade improvement, the baseline model implies a tiny increase in the unemployment rate. As we saw, this pattern is at odd with the significant estimated reduction in unemployment observed after a mining terms of trade improvement. Both type of wage rigidities can also generate a reduction in unemployment. However, the magnitude of the reduction in unemployment predicted by the model variants is very small compared to the empirical estimation. For example, wage rigidity in terms of importable is the model variant that can magnify the fall in unemployment most significantly and the reduction in unemployment rate is still four times smaller than in the estimated response.

Finally, the initial real appreciation (measured again for the rise in the relative price of non-tradable) and the sequent real depreciation estimated in the data cannot be replicated by the models and its variants. This inability of the model in generating a sizeable real appreciation due to mining price increase together with a small fall in the unemployment rate reflects that, in principle, business cycle should not be significantly affected by mining price fluctuations because the share of mining production in total GDP is small (10%). Hence, the model economy requires additional propagation mechanisms to reconcile the observed response to mining price movements.

[16]Note that a wage rigidity in terms of importable can be partially generated by a wage rigidity in terms of consumption price combined with a high negative correlation between wage in terms of consumption price and the consumption price index. The latter can be defined as the real exchange rate and this correlation implies that when the real exchange depreciates, the real wage increases.

Job Separation Rate and More Wage Rigidity We noted that in the empirical estimation the fall in unemployment after a rise in mining price is attributed in part to a reduction in the destruction rate, which is a channel that is not modelled in current version of the model. As a simple way to analyze how the response are modified under this possibility we consider a shock in the separation rate that reduces in combination with the mining terms of trade increase. We calibrate the size of this shock in order to replicate the observed magnitude of highest reduction in the separation rate that is observed in the estimated SVAR after a mining price increase. The presence of changes in the separation rate seems less important in the estimated response after non-mining terms of trade shocks. [17] Thus, figure 14 presents the response of the main variables after a mining terms of trade rise in combination with a fall in the job separation rate. This possibility induce an additional fall in the unemployment rate in the baseline calibration. This increases the expansion of non-tradable employment. However, the size of the reduction in unemployment is still very low compared with the estimated responses and the fall in the finding rate is exacerbated. Figure 14 also shows the response after mining terms of trade rise in the case of wage rigidity. As expected, the presence of wage rigidity amplify the increase in the non-tradable employment and the fall in the unemployment rate helping to reconcile better the model predictions with the estimated responses. Wage rigidity in terms of importable is better equipped to replicate the estimated responses than the case in terms of the consumption price index. Nevertheless, even in the case of wage rigidity in terms of importable, the presence fall in the job separation rate induces a fall in the job finding rate, a pattern that is inconsistent with the estimated response. Also, all model variants are unable to generate a rise in the exportable employment and non-tradable labor productivity as it is observed in the estimated SVAR.

As a extreme case to analyze the merits of wage rigidity, we consider an alternative calibration where the inertia in wages –either in terms of importable or consumption price– is very high ($\phi = 0.99$). Thus, figure 15 reproduces the responses to a mining terms of trade improvement in combination to a fall in the job separation rate in these extreme cases of wage rigidities together with the estimated response and the baseline calibration. Under the extreme wage rigidity in terms of importable, the reduction in the unemployment rate is quantitatively similar to the estimated response and it implies a rise in the job finding in a magnitude close to what is estimated in the data. Wage rigidity in terms of consumption price is less success along these dimensions. Moreover, under wage rigidity in terms of importable, the fall in the exportable employment is almost muted, but it is unable to induce a increase in

[17] The persistence of this separation rate shock is estimated in the data and it closely to 0.7 in quarterly terms.

exportable employment and non-tradable labor productivity as it is estimated in the SVAR.

Hence, the model with very high wage rigidity in terms of importable combined with the observed reduction in the job separation rate is relatively successful in replicating the estimated amplification and propagation of mining terms of trade shock in labor market variables. However, this very high wage rigidity implies that labor market variables will also reacts more intensely after non-mining terms of trade shocks. Figure 16 depicts the responses after a non-mining terms of trade increase under the extreme cases of wage rigidity. In this exercises we abstract of changes in the job separation rate because in the estimated response to non-mining price is not significant statistically. As it can be observed, the reduction in the unemployment rate is significantly magnified under wage rigidity in terms of importable with a very high increase in the job finding rate. These movements are far from the estimated responses and therefore, it challenges the adequacy to have high wage rigidity in terms of importable in response both type of terms of trade shocks.

6 Final Remarks

In this paper we analyze the channels through which terms of trade affect labor market variables in Chile. In doing so, we document the main business cycles properties of labor market variables highlighting the importance of terms of trade movements. We also use a structural vector autoregressive model to estimate the empirical responses of labor market variables to terms of trade shocks in the case of Chile. Despite the fact that mining sector represents a small fraction of GDP which is not closely related to other production sectors, we found that mining terms of trade shocks are a significant driver of fluctuations in labor market variable such as unemployment rate, job finding and destruction rate. We then develop a multi-sector model with search frictions that generates fluctuations in the main labor market variables. Using a calibrated version of this model for Chile, we analyze the ability of the model to replicate the observed response of labor market variables to terms of trade shocks. We find that the model can predict quantitatively the effects of labor market variables to non-mining terms of trade shock introducing wage rigidity. Although the model is able to obtain responses to mining price changes qualitatively similar to what is observed in the data, it falls short to the estimated magnitude of reduction in unemployment that follows to a rise in mining prices. A higher wage rigidity can helps to generate a stronger falls in unemployment after a mining price rise. Finally, the model remarks a more intense sectoral labor reallocation in response to terms of trade shocks than the amount estimated in the data.

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	Std. Dev.	Auto - Corr.	Correlation with							
			Productivity		Output		Mining ToT		Non Mining ToT	
Unemployment Rate	0.109	0.837	-0.473	2 (-0.69)	-0.694	1 (-0.73)	-0.041	3 (-0.47)	0.141	-2 (0.32)
Vacancies	0.117	0.737	0.526	1 (0.53)	0.717	–	0.221	2 (0.38)	-0.096	6 (0.26)
Employment	0.011	0.732	-0.027	3 (0.37)	0.544	1 (0.63)	-0.057	-6 (0.33)	-0.312	-6 (0.43)
Wages / CPI	0.009	0.679	0.269	-1 (0.42)	0.116	-3 (0.37)	0.439	-1 (0.5)	0.408	-1 (0.43)
Wages / PM	0.046	0.701	0.162	-2 (0.37)	0.082	-2 (0.38)	0.495	-1 (0.57)	0.296	–
Productivity	0.017	0.666	–	–	0.822	–	0.376	2 (0.54)	0.285	-5 (-0.44)
Output	0.020	0.754	0.822	–	–	–	0.282	2 (0.56)	0.065	3 (0.31)
Mining ToT	0.154	0.846	0.376	-2 (0.54)	0.282	-2 (0.56)	–	–	0.462	–
Non Mining ToT	0.050	0.681	0.285	5 (-0.44)	0.065	-3 (0.31)	0.462	–	–	–

Notes: The business cycle moments were computed using Hodrick - Prescott filtered data with a value of 1,600 for the smoothing parameter. The columns under "correlation with" report (i) the contemporaneous correlation and (ii) the lead (negative number) or lag (positve number) at which the correlation between the variable at date t and each of the variables in the line above at date t - i reaches its (absolute) maximum. The numbers in parentheses report the correlation at this lead or lag.

Table 1: Summary Statistics

	Std. Dev.	Auto - Corr.	Correlation with							
			Productivity		Output		Mining ToT		Non Mining ToT	
Emp. - Unemp.	0.1111	0.4489	-0.2853	1 (-0.5)	-0.5379	–	-0.0778	3 (-0.26)	0.1241	3 (-0.24)
Emp. - Out of L.F.	0.086	0.1359	0.4034	–	0.1924	–	0.1877	3 (0.29)	0.0369	3 (0.26)
Unemp. - Emp.	0.0732	0.2143	0.4887	–	0.4741	–	0.2359	2 (0.41)	0.0309	3 (0.16)
Unemp. - Out of L. F.	0.1123	0.156	0.4278	–	0.4233	–	0.1664	2 (0.39)	-0.0579	6 (0.31)
Out of L. F. - Emp.	0.0715	-0.0069	0.2209	1 (0.44)	0.431	–	0.1385	2 (0.37)	-0.1673	4 (0.27)
Out of L. F. - Unemp.	0.1328	0.2773	-0.1028	1 (-0.15)	-0.1265	1 (-0.22)	0.0649	3 (-0.16)	-0.0336	6 (0.21)

Notes: The business cycle moments were computed using Hodrick-Prescott filtered data with a value of 1,600 for the smoothing parameter. The columns under "correlation with" report (i) the contemporaneous correlation and (ii) the lead (negative number) or lag (positive number) at which the correlation between the variable at date t and each of the variables in the line above at date t - i reaches its (absolute) maximum. The numbers in parentheses report the correlation at this lead or lag.

Table 2: Summary Statistics: Gross Flows

	Contribution to variance of Unemployment Deviation
Employment - Unemployment	0.5063
Employment - Inactivity	-0.0366
Unemployment - Employment	0.3054
Unemployment - Inactivity	0.0927
Inactivity - Employment	0.0764
Inactivity - Unemployment	0.0548

Table 3: Variance Decomposition: Unemployment Rate

Table 4: Parameters for baseline calibration

Household		Other	
β	0.9967	ϵ	0.4000
σ	1	$\mu''(\delta)/\mu'(\delta)$	0.1250
b	0.4757	$\overline{B}$	0.0000
φ	0.4706	$\overline{Y}^{Co}/\overline{Y}$	0.1000
ω	1	$\left((\bar{Y}^X - \bar{c}^X) + \bar{Y}^{Co}\right)/\bar{Y}$	0.3500
χ	0.5145	ψ	0.0001
Firms		**Shocks**	
α^X	0.6439	$\rho_{P^{C_o}}$	0.9495
α^N	0.3430	ρ_{P^X}	0.8034
δ	0.0051	ρ_{r^*}	0.8934
		$\sigma_{P^{C_o}}$	7.08%
		σ_{P^X}	2.96%
		σ_{r^*}	0.22%
Labor market			
$\bar{u} = \bar{u}^X + \bar{u}^N$	0.0858		
$\bar{u}^X$	0.0300		
$\bar{u}^N$	0.0558		
$\bar{n}^X$	0.3200		
$\bar{n}^N$	0.5942		
$\bar{v}^X$	0.0027		
$\bar{v}^N$	0.0027		
$\gamma = \eta$	0.5000		
A	1.4009		
$\bar{\rho}^X$	0.9779		
$\bar{\rho}^N$	0.9779		
$\bar{\pi} = \bar{\pi}^X = \bar{\pi}^N$	0.2355		
$\bar{q} = \bar{q}^X = \bar{q}^N$	8.3300		
$\bar{\theta} = \bar{\theta}^N = \bar{\theta}^X$	0.0283		

Figure 1: Unemployment Rate in Chile

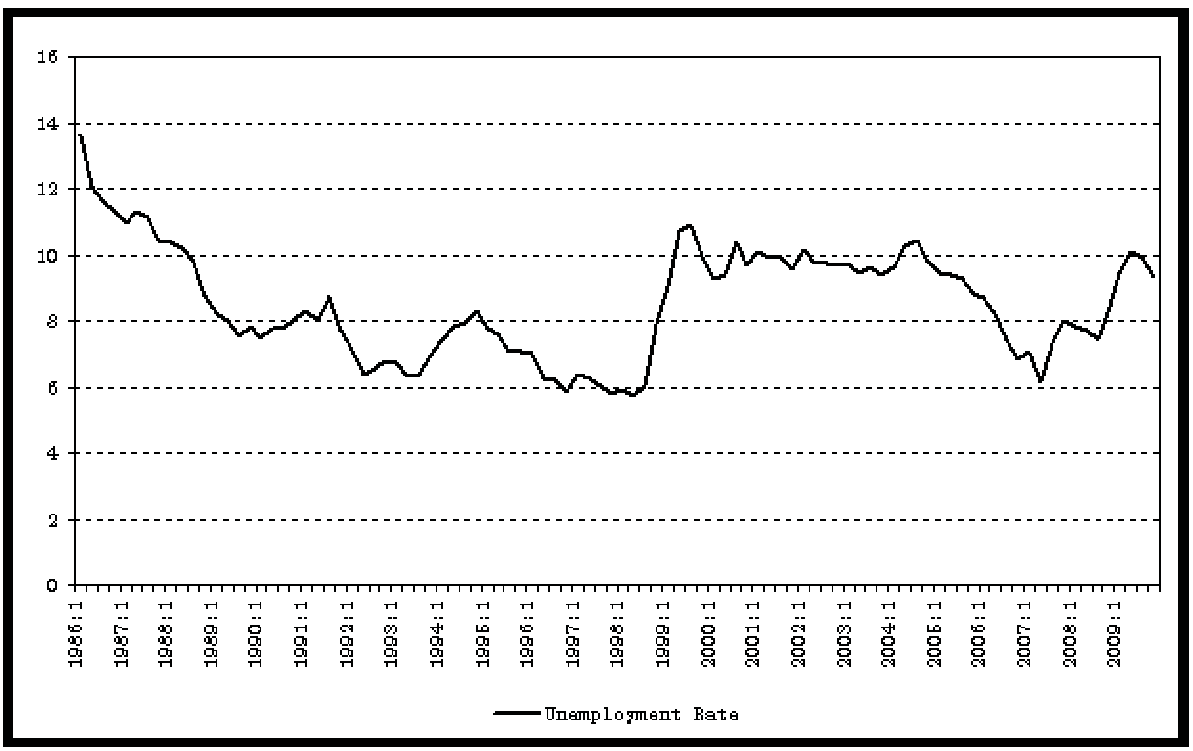


Figure 2: Correlation with lags and leads of Mining Terms of Trade

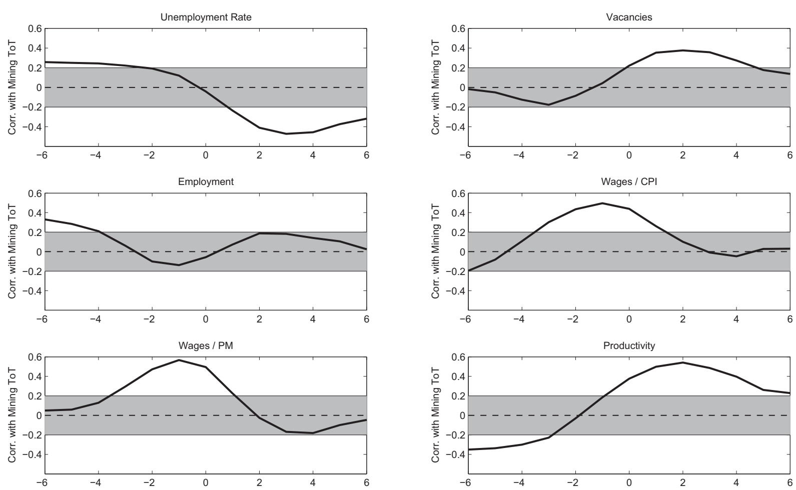


Figure 3: Correlation with lags and leads of Non-Mining Terms of Trade

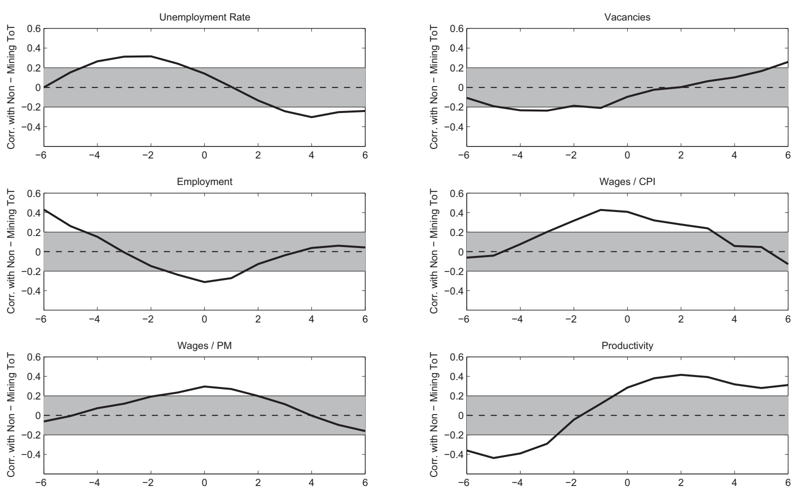


Figure 4: Correlation with lags and leads of Mining Terms of Trade: Gross Flows

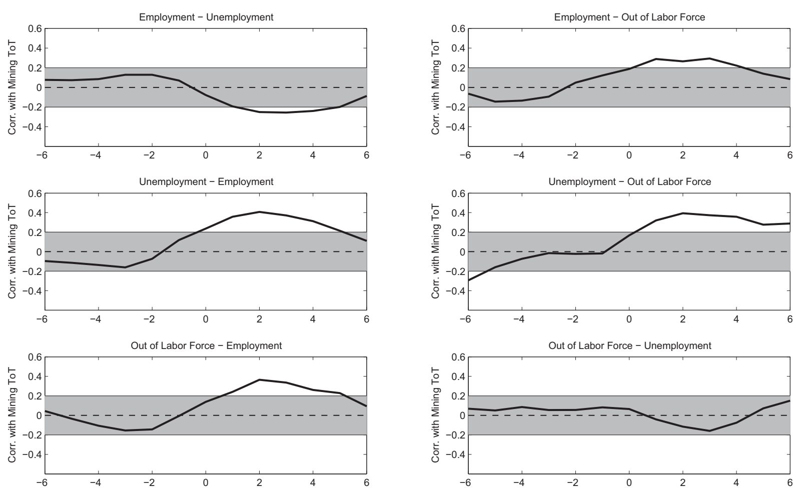


Figure 5: Correlation with lags and leads of Non-Mining Terms of Trade: Gross Flows

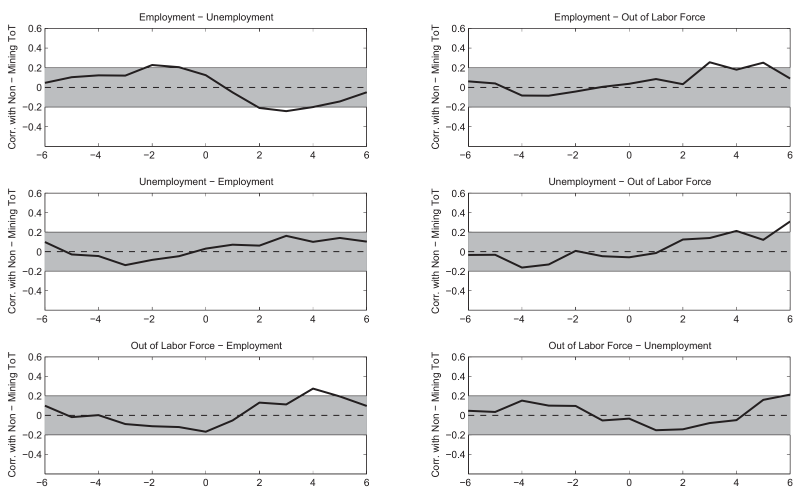


Figure 6: Estimated Impulse Response to a One Standard Deviation Innovation in non-Mining (P^X) Terms of Trade

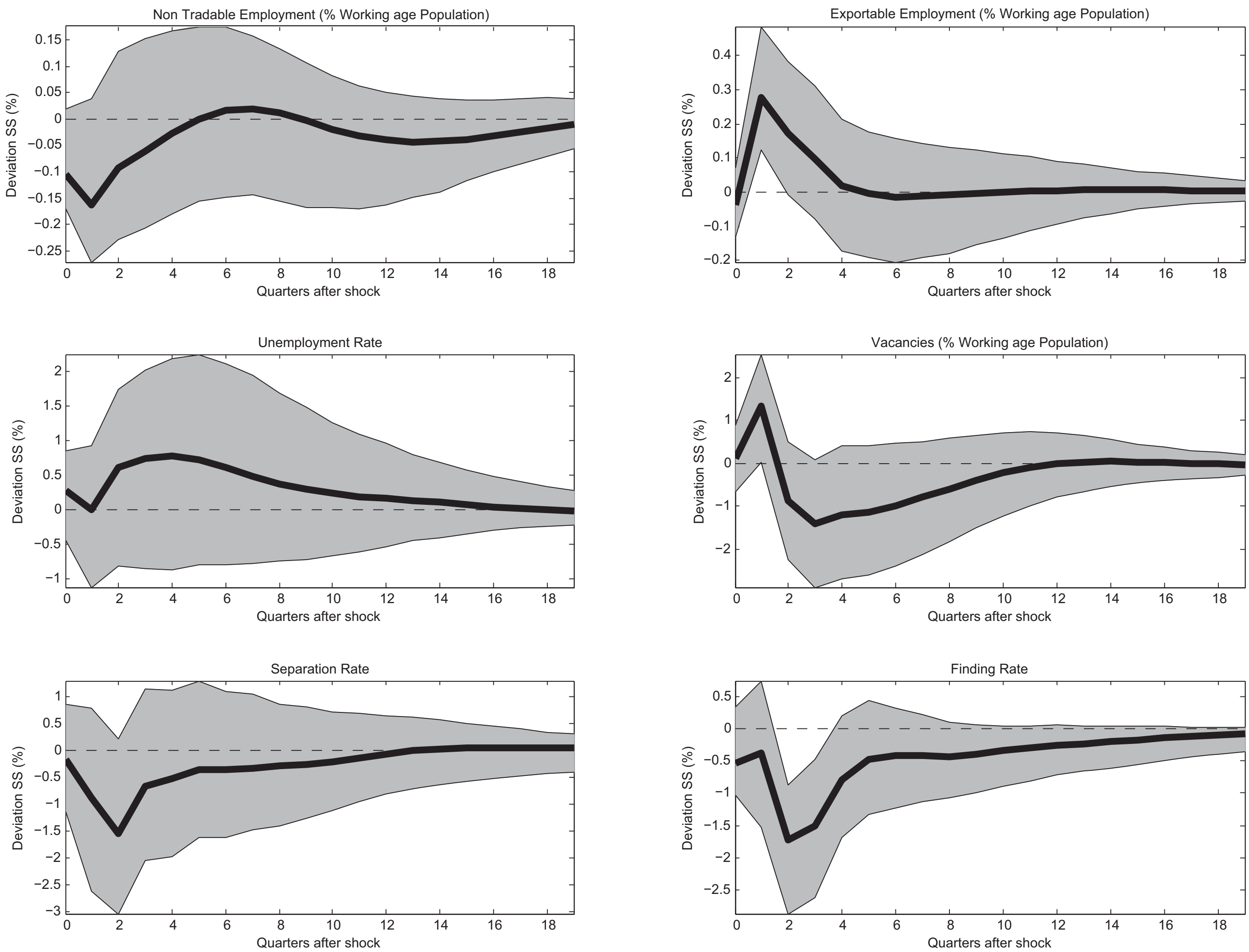


Figure 7: Estimated Impulse Response to a One Standard Deviation Innovation in Mining (P^{Co}) Terms of Trade

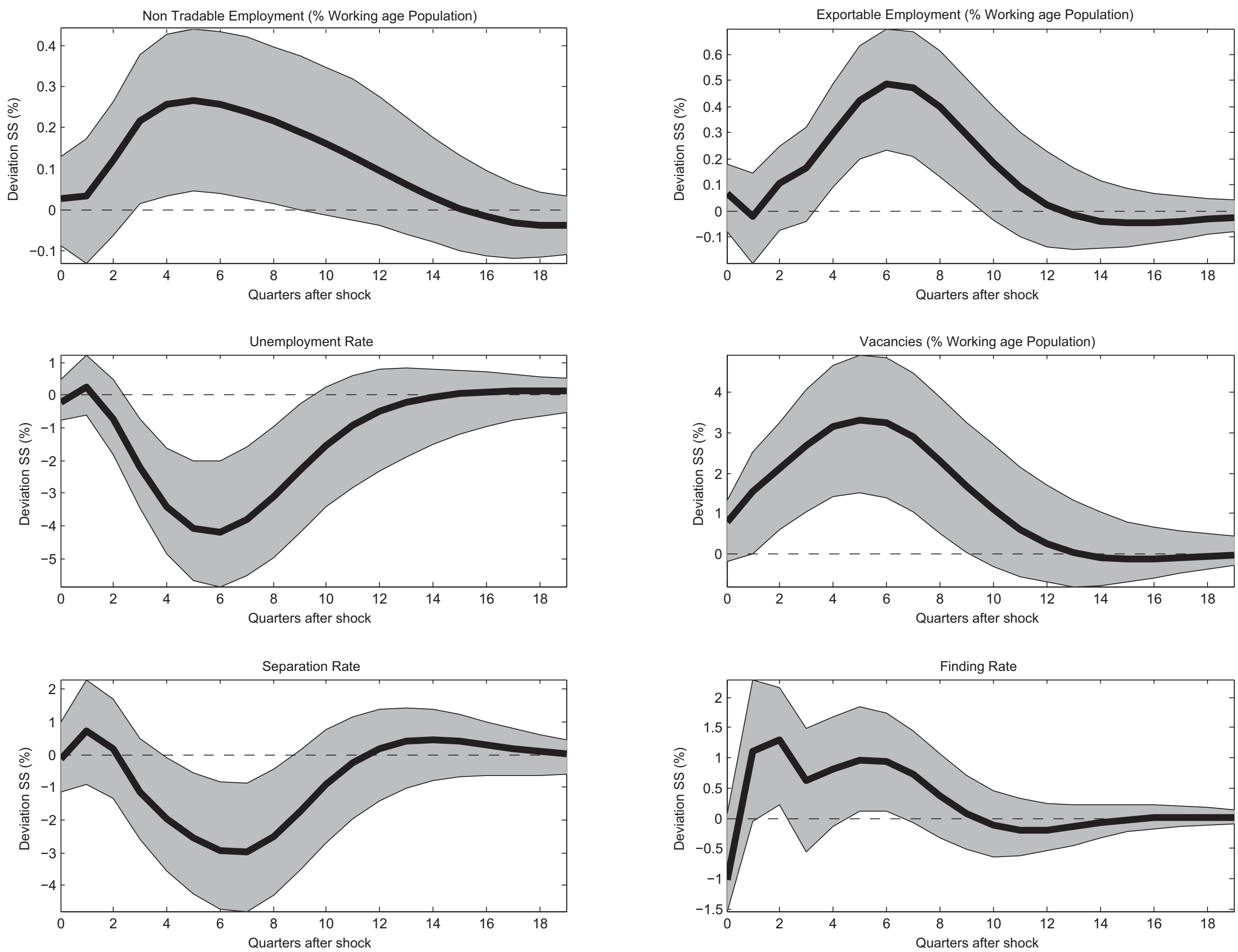


Figure 8: Baseline Model. Sectoral Response to a One Standard Deviation Innovation in non-Mining (P^X) Terms of Trade

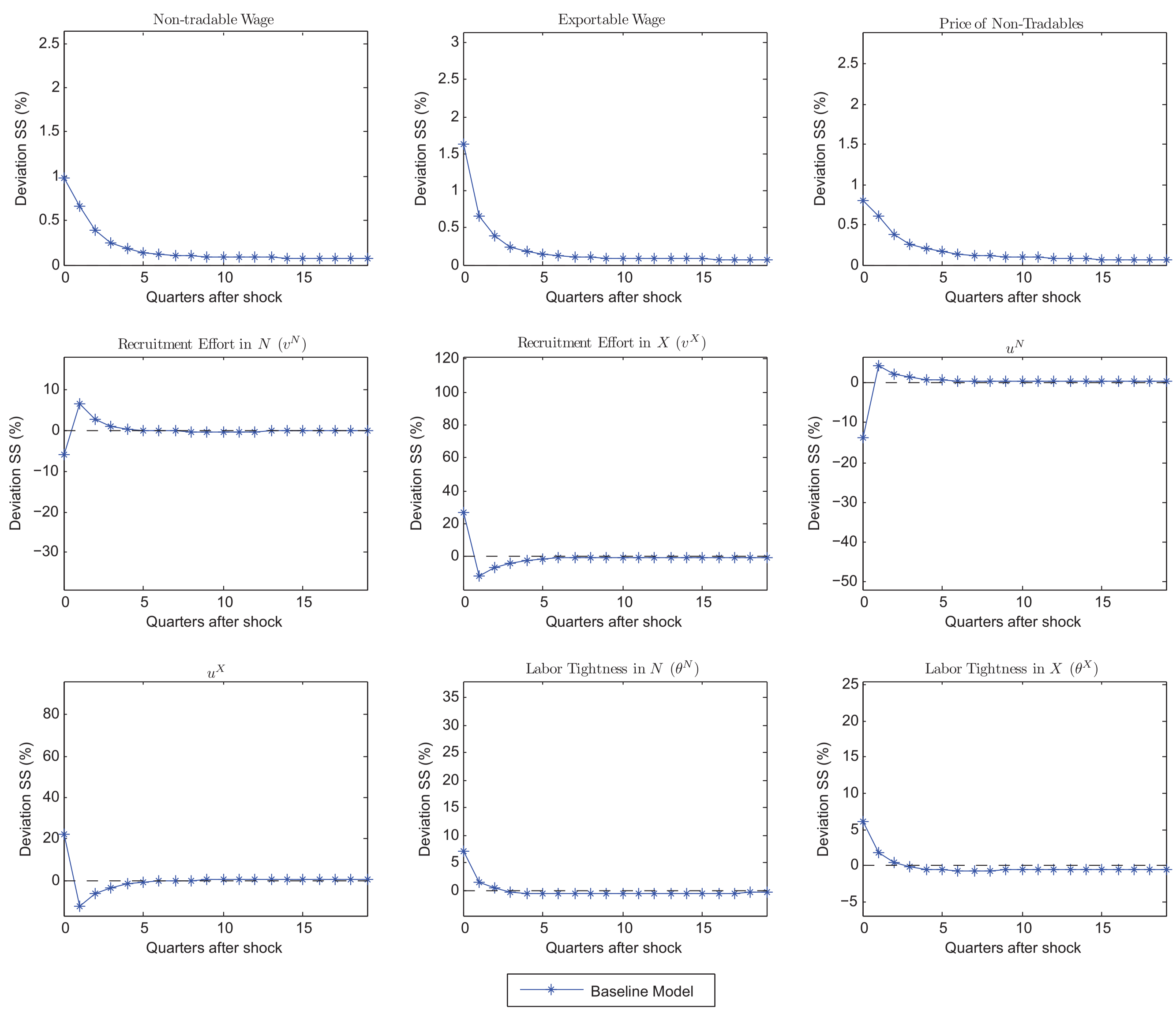


Figure 9: Baseline Model and Estimated Impulse Response to a One Standard Deviation Innovation in non-Mining (P^X) Terms of Trade

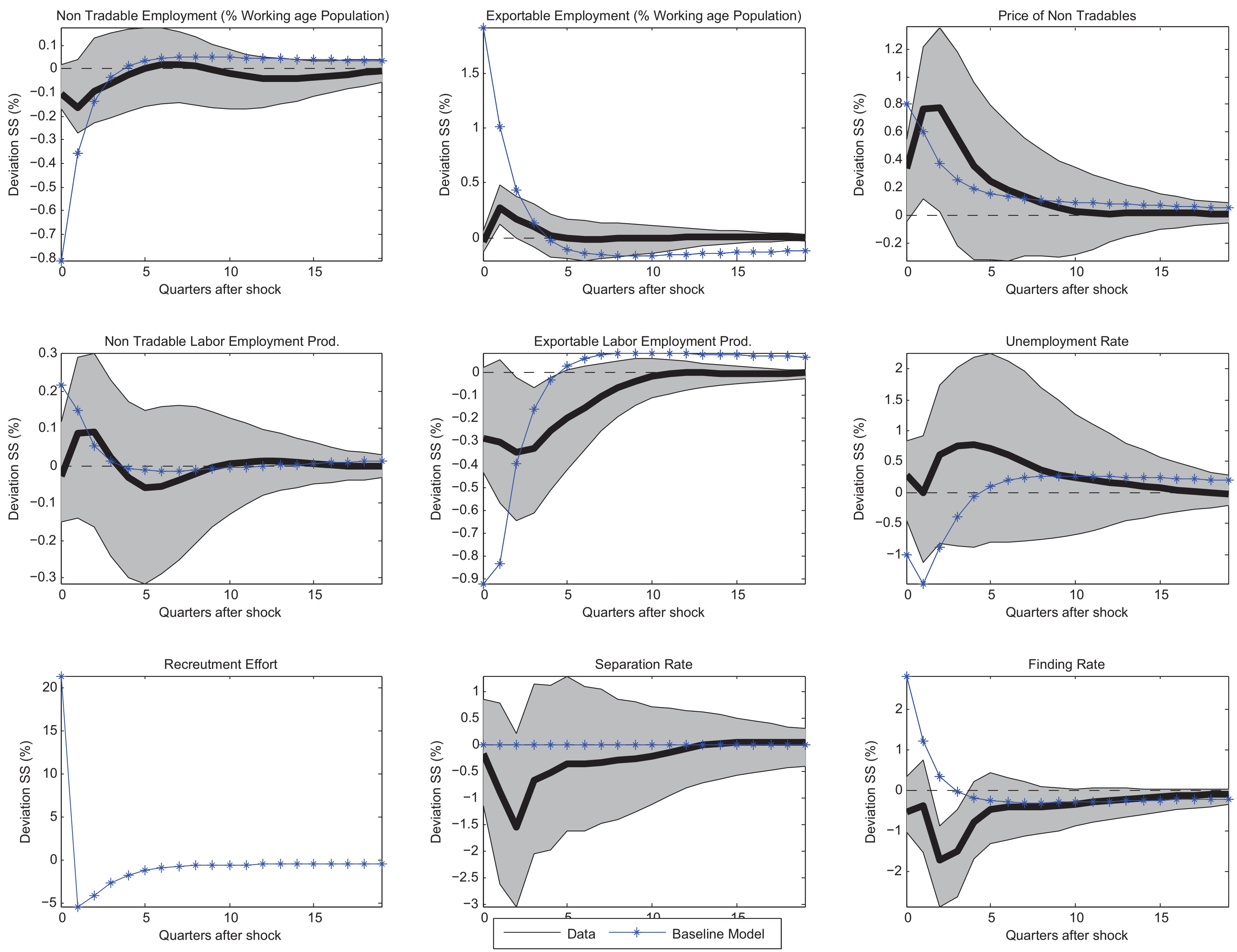


Figure 10: Baseline Model Sectoral Response to a One Standard Deviation Innovation in Mining (P^{Co}) Terms of Trade

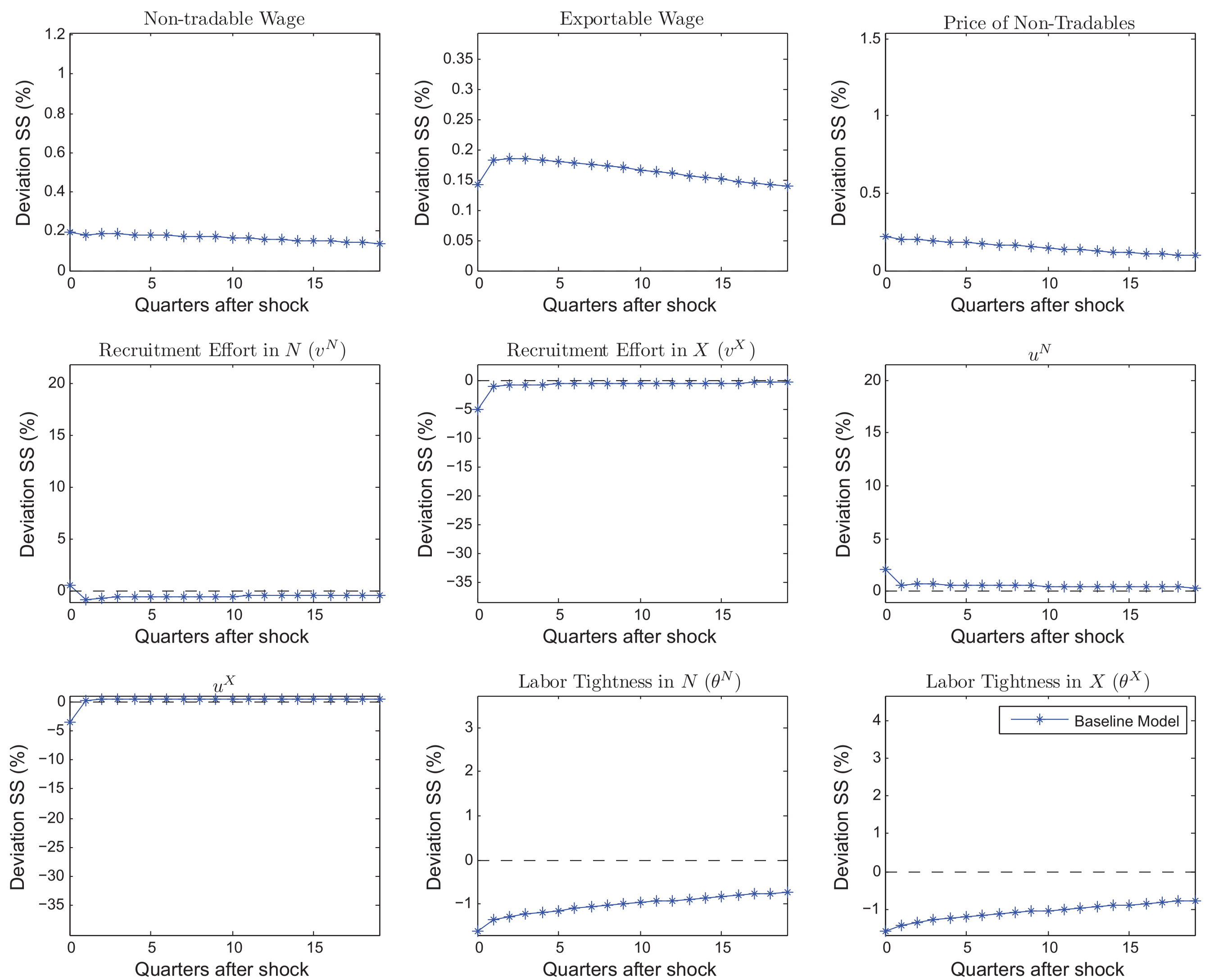


Figure 11: Baseline Model and Estimated Impulse Response to a One Standard Deviation Innovation in Mining (P^{Co}) Terms of Trade

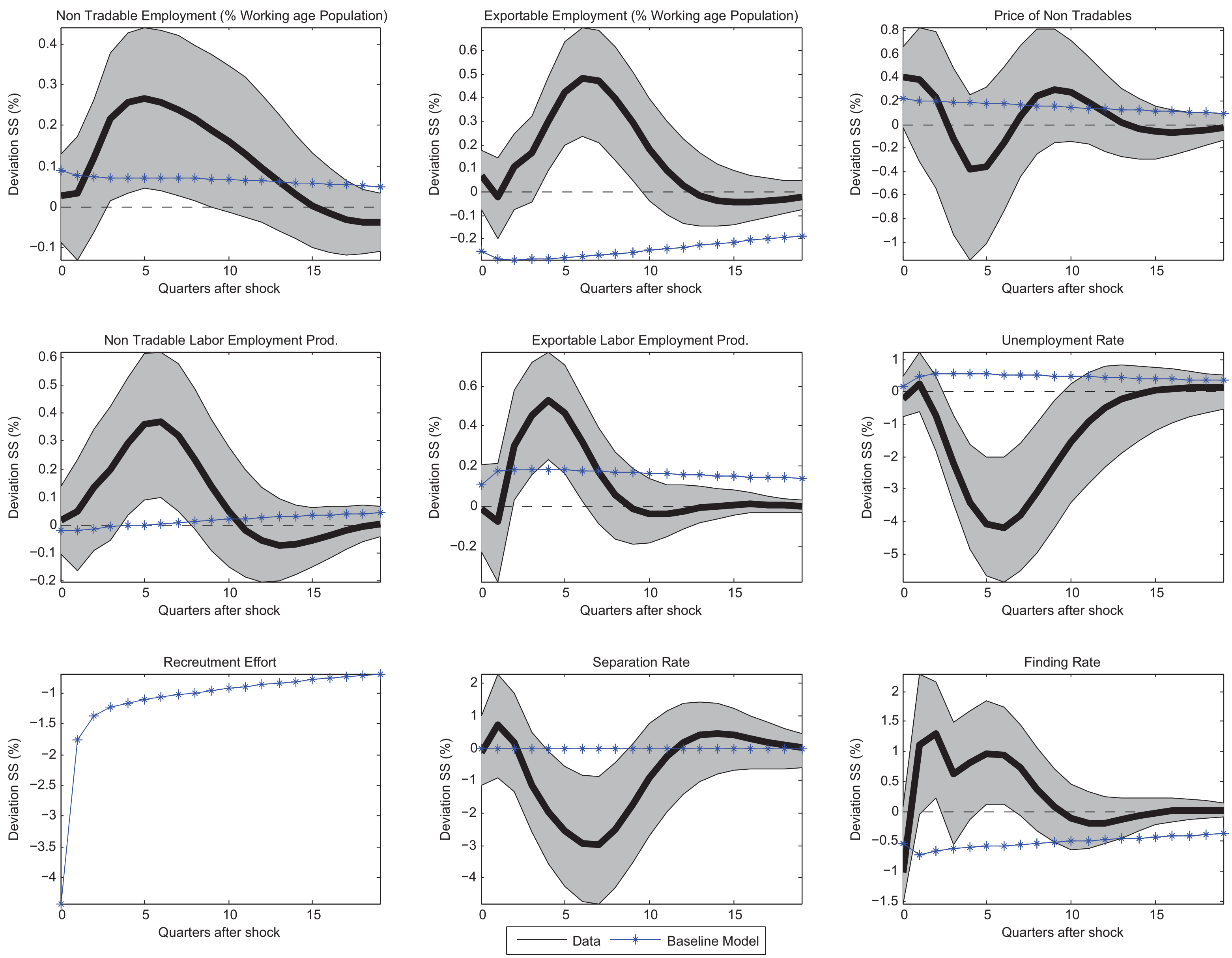


Figure 12: Sensitivity Analysis. Other Models and Estimated Impulse Response to a One Standard Deviation Innovation in non-Mining (P^X) Terms of Trade

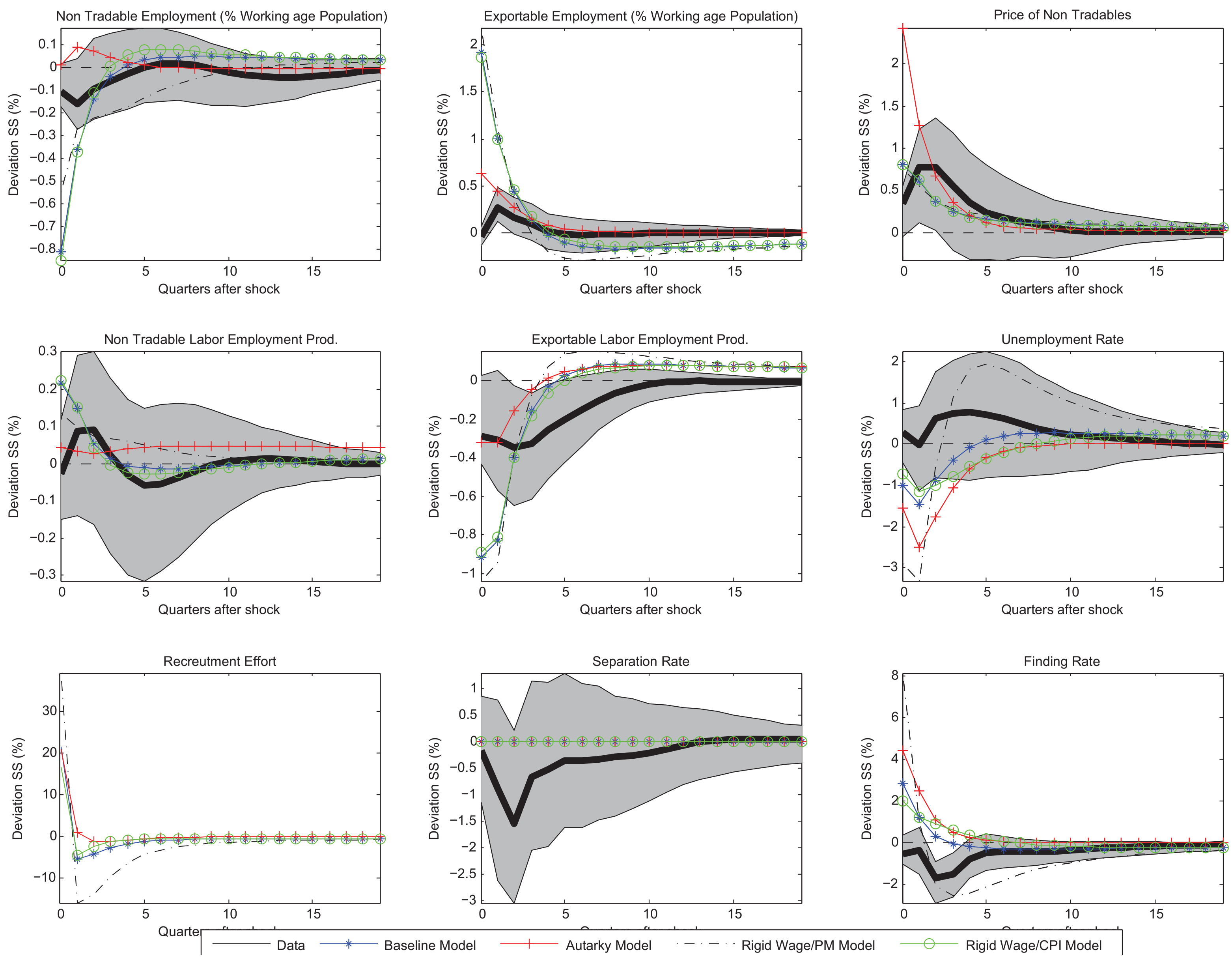


Figure 13: Sensitivity Analysis. Other Models and Estimated Impulse Response to a One Standard Deviation Innovation in Mining (P^{Co}) Terms of Trade

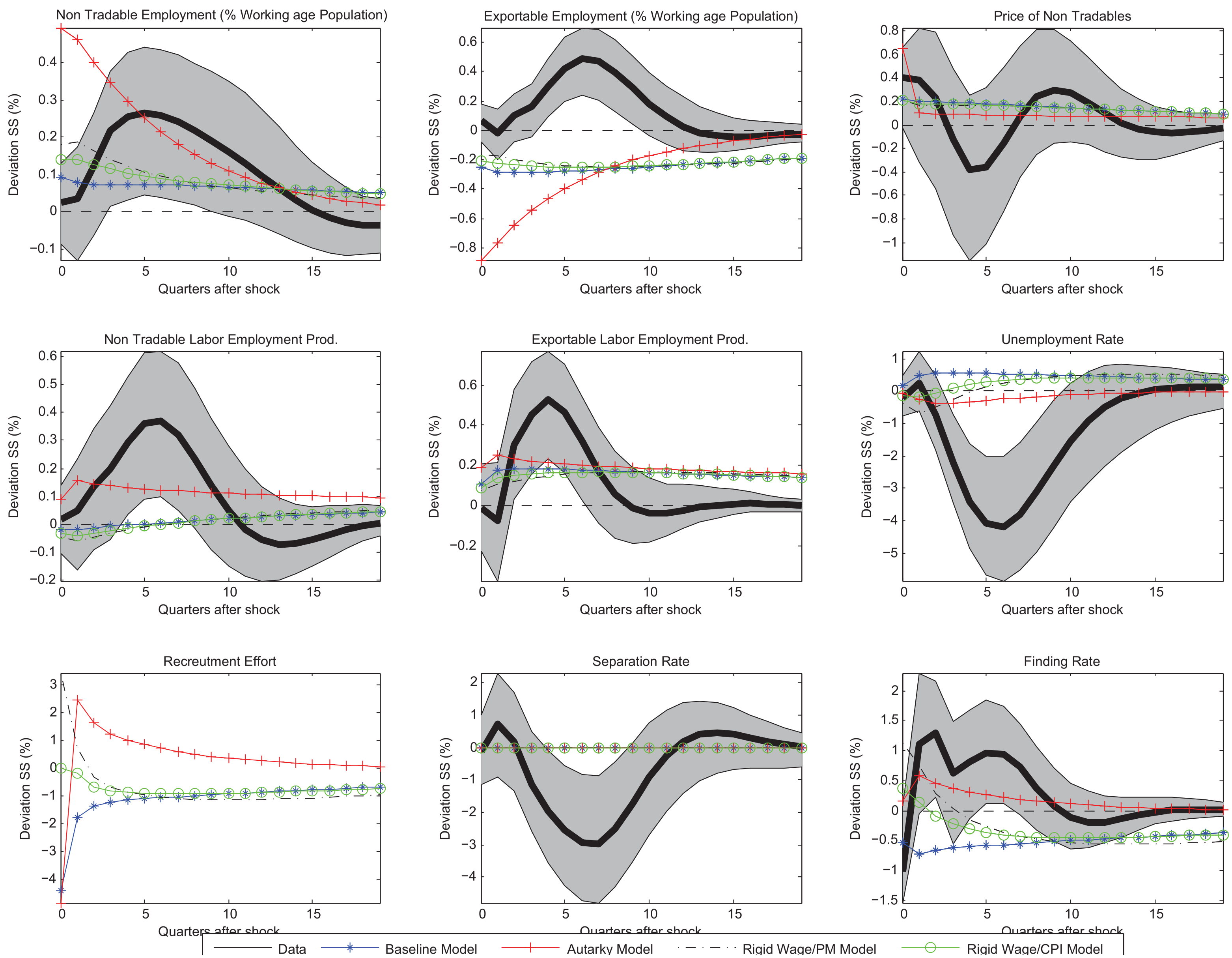


Figure 14: Sensitivity Analysis. Response after Mining Terms of Trade increase and Job Separation fall.

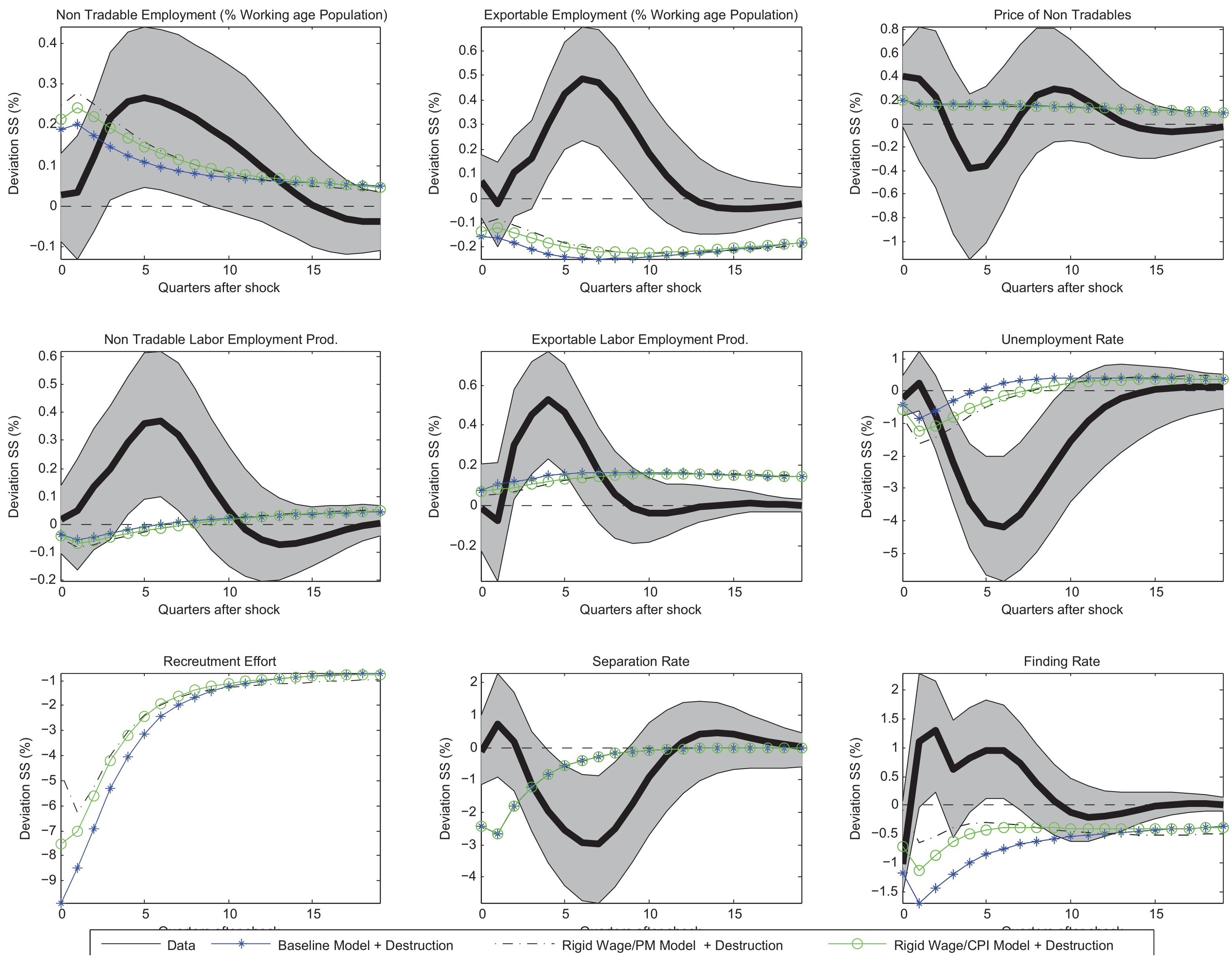


Figure 15: Sensitivity Analysis. Response after Mining Terms of Trade increase and Job Separation fall under Extreme Wage Rigidity.

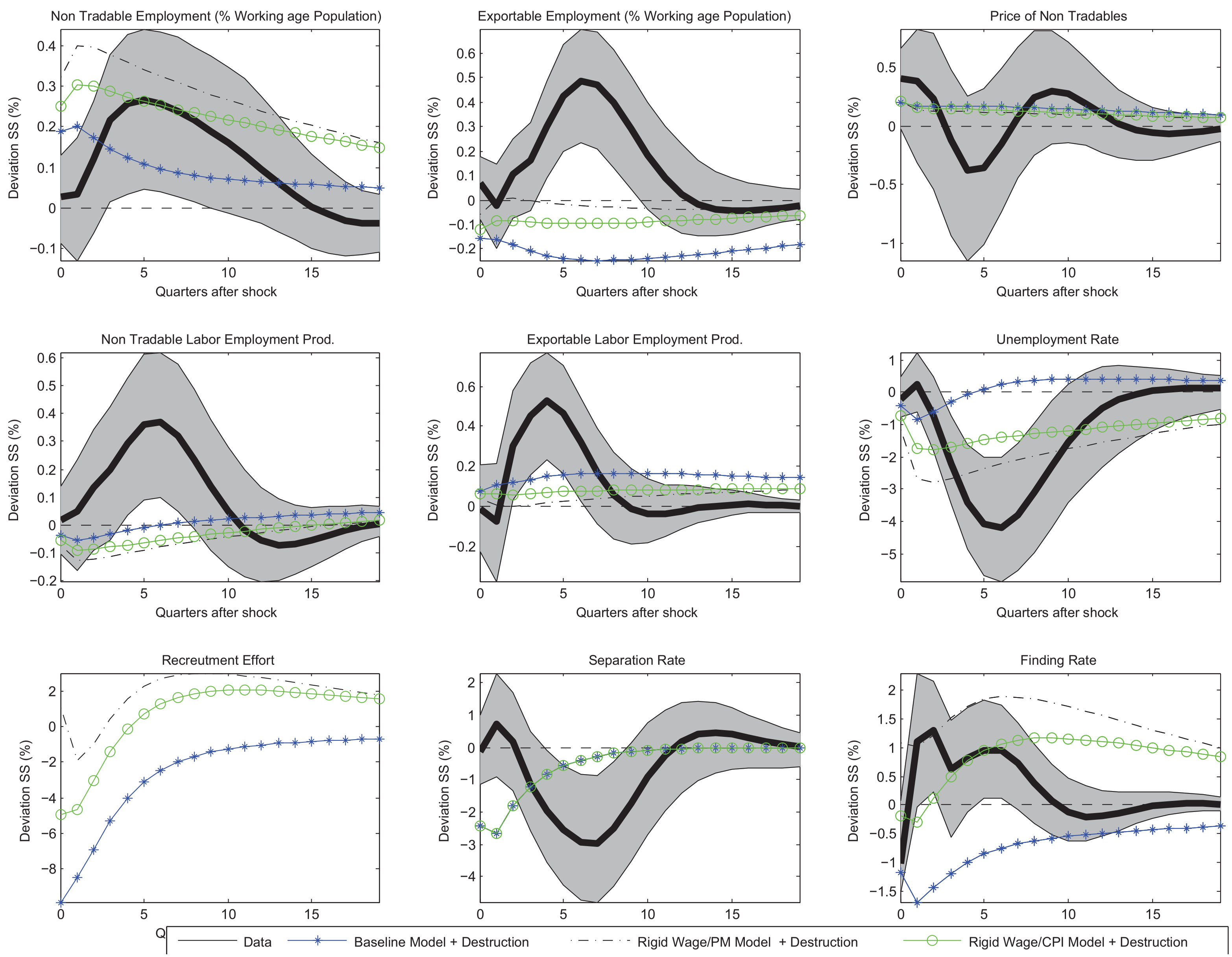
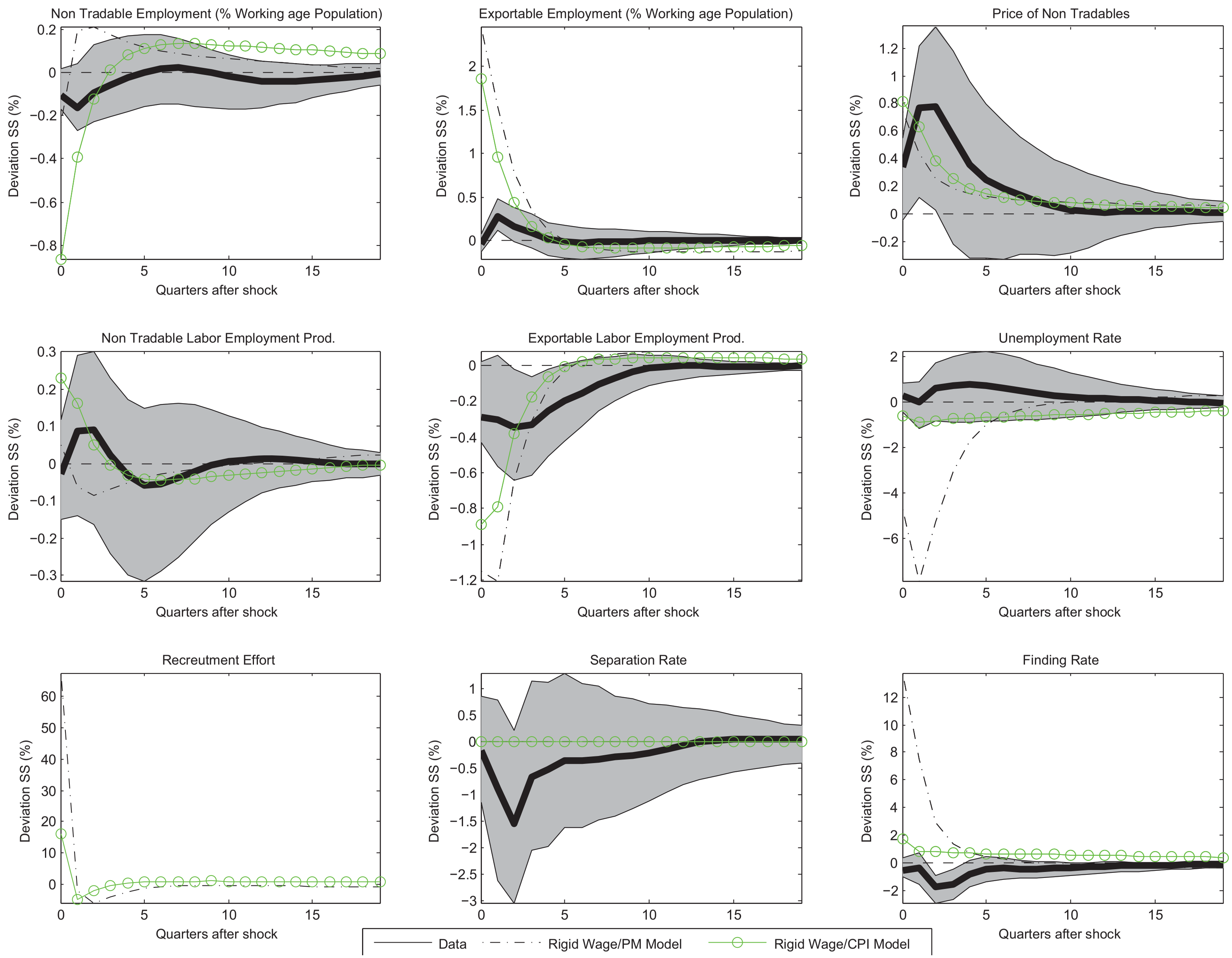


Figure 16: Sensitivity Analysis. Response after Non-Mining Terms of Trade increase under Extreme Wage Rigidity.



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