LABOR MARKET DYNAMICS
AFTER NOMINAL DEVALUATIONS*

Andres Drenik†
Columbia University

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Abstract. This paper studies two channels through which exchange rate policy affects the real economy. First, if nominal wages do not decrease during a recession, a nominal devaluation of the currency – as opposed to a fixed exchange rate – reduces unemployment by lowering wages in real terms. However, if not all wages are equally rigid, sectoral labor markets respond differently under different exchange rate regimes and redistributive effects arise. Second, nominal devaluations can have an effect on the real value of nominal asset positions. The desirability of a nominal devaluation is analyzed in the context of a quantitative small open economy model. The model features heterogeneous workers and sectoral labor markets that differ in the degree of nominal rigidities. Using data from Argentina, I estimate the model to match aggregate and worker-level moments regarding labor market choices. The model predicts that fixed exchange rate regimes reduce employment and welfare during a recession. A devaluation that does not affect the real value of workers’ nominal positions improves the overall well-being of workers, but entails a redistribution of welfare across certain groups of workers. Revaluation effects can be strong enough to overcome the labor market gain of a nominal devaluation.

Keywords: Currency devaluation, heterogeneous nominal wage rigidity, heterogeneous workers.

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† Department of Economics, Columbia University. Email: ad3376@columbia.edu.
1. Introduction

One of the traditional arguments in favor of nominal exchange rate devaluations during recession periods is that, in the presence of downward nominal wage rigidities, devaluations can accelerate the decline in real wages in markets affected by negative shocks. By reducing firms’ real labor costs, a devaluation can limit the recessionary effects on employment. However, this paper shows that exchange rate policy not only affects aggregate variables, but that it can also have redistributive consequences. If wages are nominally more rigid in some sectors than in others, devaluations can generate winners and losers via asymmetric effects on employment and real wages across groups of workers. Additionally, devaluations can have an effect on the real value of households’ nominal asset positions, which could outweigh the labor market benefits or costs for certain groups of workers. The aim of this paper is to analyze these distributional effects.

This paper develops and estimates a quantitative model of a small open economy to analyze the aggregate and redistributive impact of a nominal exchange rate devaluation. The model has two key ingredients. First, there are multiple productive sectors that differ in the degree of downward nominal wage rigidities. Second, there is a rich set of heterogeneous workers that make discrete sectoral labor supply decisions subject to search frictions. I use the model to analyze the dynamics of an economy during a recession episode under different exchange rate regimes. In particular, I analyze these dynamics under a fixed exchange rate and under a nominal devaluation in an economy that has suffered a productivity shock. In this analysis, I also consider the wealth effects that an unexpected increase in the nominal exchange rate has on the real value of agents’ assets and liabilities. I discipline these quantitative predictions by estimating the model and matching micro and macro-moments from the 2001 Argentine devaluation episode, which provides a natural application of my framework.

I find that devaluations entail substantial welfare redistribution. If devaluations do not affect the real value of nominal positions, the model predicts that a devaluation reduces the average welfare cost of a recession relative to a fixed exchange rate regime. Despite the average worker being better off, devaluations do harm certain groups of workers at the expense of others due to asymmetric responses across labor markets. When also considering the impact of a devaluation on nominal asset positions, I find revaluation effects to be strong enough to

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1 Eichengreen and Sachs (1985) argue that monetary shocks, combined with the gold standard, were a major cause of the Great Depression. They conclude that a nominal devaluation (or abandonment of the gold standard) was one of the first steps towards economic recovery since it helped reduce wages in real terms.

2 Distributional effects might explain why the prospects of a large devaluation divide public opinion and are politically delayed. For example, a recent poll shows that the Greek society is fairly divided in their preference towards Greece leaving the Euro (“What were the Greeks thinking? Here’s a poll taken just before the referendum.”, Washington Post, July 9, 2015). See Cermeño et al. (2010) for empirical evidence about the political business cycle of exchange rate policy that shows that nominal devaluations occur more frequently after elections.
overcome a large fraction of the labor market gains. These negative revaluation effects are correlated with the labor market costs of a devaluation, which means that the welfare of a certain group of workers is negatively affected by both effects. Once these two effects are taken into account, at least 40 percent of workers would vote in favor of keeping the exchange rate fixed during the recession.

In the first part of the paper, I motivate the analysis with evidence from the nominal devaluation experienced in Argentina in 2001. In that year, the country entered into a recession, during which aggregate output fell by more than 10 percent relative to trend. The currency peg was abandoned, and the currency depreciated by more than 200 percent. Using micro-data from the Argentinian Household Survey, I document a heterogeneous degree of downward nominal wage rigidity across segments of the labor market. I focus on the distinction between formal and informal workers (those whose employer does not pay mandatory social security contributions). I categorize them as unionized and competitive, respectively. I separately analyze the evolution of nominal wages paid in both sectors and find that the average unionized nominal wage remained constant during the episode. By contrast, nominal competitive wages were more flexible and experienced a drop of up to 24 percent from 1995 to the trough of the recession in 2002 (with a sharp decline during the first quarters of the recession). This heterogeneity in the degree of downward nominal wage rigidities had an observable impact on labor market variables, such as sectoral employment and probabilities of sectoral transitions. In order to understand the source of this heterogeneity, I present additional evidence from a contract-level data set on the contracts signed between unions and firms during the period of analysis. I find that few new contracts were signed during the recession period and that the bargaining activity increased only after inflation started to rise. This finding suggests that in fact unions played a big role in generating nominal wage rigidities.

In order to understand the impact of heterogeneous nominal wage rigidities and the nominal devaluation in this episode, I develop a dynamic small open economy model. My model features a tradable and a non-tradable final good. I assume that the labor market operating in the tradable sector is fully unionized. However, there are two intermediate non-tradable varieties in the economy. One is produced by a sector with a unionized labor market, and the other is produced by a sector featuring a competitive labor market. The feature that distinguishes both sectors is that in the unionized sector wages are the outcome of a bargaining process subject to downward nominal wage rigidities, and in the competitive sector wages are flexible and clear the market at all times. The model features a combination of an exogenous search friction and endogenous job rationing in the unionized sectors. The search friction captures the fact that it takes time to find a job. The job rationing friction arises because employment is demand determined in the unionized sector, so a mechanism is specified to ration scarce jobs among the workers that search for employment in those sectors. The
economy is populated by risk averse heterogeneous workers that differ in their idiosyncratic labor market productivity, labor market status, and wealth. In each period they decide whether to participate in the labor market or not and, conditionally on participating, in which sectors to supply their labor. Once the labor market status of the worker is determined, he makes consumption and savings decisions. There are no insurance markets for idiosyncratic risk. However, workers can accumulate foreign assets that pay an exogenous interest rate. The model is closed with a government that collects income taxes and redistributes the proceeds equally among the non-employed. There is also a representative capitalist, who is the sole owner of all the firms in the economy. In each period he receives profits from all the firms, consumes the tradable and non-tradable final goods and makes savings decisions.

To analyze the quantitative predictions of the model, I estimate the model using the Simulated Method of Moments so that its steady state equilibrium predictions match several micro and macro-moments of the Argentinian economy during the years previous to the recession. The model can replicate a rich set of moments related to the labor market. More specifically, the model can reproduce the fact that unionized wages are higher than wages paid in the competitive sector, and the probability of finding a unionized job is lower. The model is also able to generate a distribution of workers according to their labor market state and transition rates across all possible states that resemble the stock and flows of workers observed in the data.

With the estimated model in hand, I perform a series of counterfactual exercises to understand the role of nominal rigidities and the effect that nominal exchange rate devaluations have during a recession. The baseline exercise consists of analyzing the transition dynamics of an economy that is unexpectedly hit by a 20 percent drop in total factor productivity in the tradable sector, which can be also interpreted as a large shock to the terms of trade. I compare the transition dynamics of this economy across two scenarios. In the first scenario, the government keeps the nominal exchange rate fixed. In the second, I analyze the effects of an unexpected and permanent nominal devaluation similar in magnitude to the one observed during the Argentinian episode. In this exercise, I consider two extreme assumptions to isolate better the benefits and costs of a devaluation. In the first case, I assume that all assets and liabilities are denominated in foreign currency so that the devaluation does not affect the dollar value of assets. In the second case, a fraction of assets and liabilities are denominated in local currency so that the devaluation has a revaluation effect.

When the exchange rate is held fixed, the reduction in tradable output spills over to non-tradable output, which decreases by 5.6 percent on impact. The reason is that nominal unionized wages do not fall enough in the tradable sector, which lowers unionized employment. By becoming poorer, laid-off workers decrease their consumption of both goods. This reduction in the demand for non-tradable goods puts downward pressure on the wage paid
in the unionized non-tradable sector. Since this wage also does not adjust enough, unionized non-tradable employment decreases and aggregate unionized employment falls by 7.6 percent.

Part of this effect is mitigated by an increase in competitive employment. This increase occurs because a fraction of workers that lost their unionized jobs search for employment in the competitive sector. Aggregate competitive employment also increases because a fraction of competitive workers that would have made a job-to-job transition into an unionized job remains employed in the competitive sector. Both mechanisms push real competitive wages down by 17 percent. The economy also responds to the shock in the tradable sector by decreasing the price of non-tradable goods, which reflects the fact that workers become poorer and decrease their demand for those goods. Therefore, the economy experiences a mild deflation during the first quarters.

Next, I analyze the effects of a nominal devaluation. When agents’ balance sheets are denominated in foreign currency, the devaluation has two effects. First, it allows union wages to decrease in real terms. Second, it decreases the relative price of non-tradable goods, which induces a switch of consumption towards the non-tradable good. Given the size of the exchange rate devaluation, both effects prevent the shock from spilling over to the rest of the economy and keep employment unaffected.

I also consider the scenario in which the devaluation affects the real value of nominal positions. For this counterfactual, I consider the redistribution of wealth among the three types of agents: the workers, the capitalist and the government. I use data on the monetary base, loans and deposits made by the private and public sector, and government debt to compute the wealth gain or cost for each group of agents. Since the government is the biggest winner due to the revaluation of its nominal debt, I specify alternative ways in which the government can spend the windfall gain: in one case the government increases government spending in the non-tradable sector and in the other the government redistributes the gain back to non-employed workers.

In these scenarios the devaluation avoids the negative effects of nominal wage rigidities on unionized employment. However, the subsequent evolution of the economy depends on the fiscal policy implemented by the government. An increase in government expenditure generates a transitory increase in non-tradable output of 2.9 percent. However, it would be misleading to conclude from this observation that the devaluation is beneficial for all agents. Since workers lose a fraction of their wealth, aggregate workers’ consumption declines by almost 4 percent due to wealth effects. The difference with non-tradable output comes from the increase in the consumption of the capitalist and the government’s expenditure on non-tradable goods. When the government transfers the windfall gain back to non-employed workers, non-tradable output declines by 1.5 percent. In this case, the increase in government transfers subsidizes leisure and induces a fraction of employed workers to stop supplying labor.
The desirability of a nominal devaluation is analyzed by computing the welfare effects of alternative exchange rate policies for the aggregate economy, but also for the different groups of workers. The model predicts substantial heterogeneity in welfare effects relative to the steady state. On average, the recession with a fixed exchange rate generates an ex-post welfare cost equivalent to a permanent consumption drop of 1.7 percent. Workers that at the onset of the recession were unemployed or employed in the competitive sector experience the largest reduction in welfare. Their loss is due to the lower probability of finding a unionized job, which increases the labor supply to the competitive sector and decreases real competitive wages. However, the median worker that was employed in the unionized sector when the shock hit the economy is better off than in steady state. The reason is that the median unionized worker not only does not lose his job (i.e., the probability of getting laid off is well below 50%), but he also benefits from the deflation that the economy experiences.

When the government implements a devaluation, the average welfare cost of a recession is equivalent to a 0.2 percent fall in permanent consumption. The gain is mostly received by competitive workers, who thanks to the devaluation do not see their real wages fall severely, and unemployed workers, who can find a job in the unionized sector. The median unionized worker is worse off with the devaluation (relative to the steady state) due to the decrease in real unionized wages.

When revaluation effects are taken into account, the welfare consequences of a devaluation are different. Under the scenario in which the government uses the windfall gain to increase government consumption (which does not enter in the utility of other agents), I find that there is an average welfare cost of a devaluation equivalent to a permanent consumption drop of 1.8 percent. Despite undoing the effects of nominal frictions, the devaluation provides an additional small welfare cost to the workers relative to the scenario with a fixed exchange rate. In particular, workers employed in the unionized sectors and those with higher levels of assets lose the most from this policy. The reason why unionized workers are more affected is because these workers earn the most and, therefore, accumulate more assets while employed. If instead the government redistributes the extra resources back to non-employed workers, I find a small average welfare gain relative to the steady state. This result is not surprising since the country is a net debtor in steady state and the decrease in the real value of government debt is rebated back to the workers. Nonetheless, redistributational effects across groups of workers remain.

Finally, I study the welfare effects of exchange rate policy from an ex-ante perspective. In other words, I ask the following question: if, during a recession, workers are given the opportunity to vote, would they vote in favor of keeping the exchange rate fixed or would they prefer to devalue the currency? I find that, from an ex-ante perspective, a vast majority of workers would vote in favor of a devaluation if it does not have an effect on the real value
of nominal positions. However, in the scenario in which devaluations have revaluation effects and the government spends the windfall gain in non-tradable goods, at least 40% of workers would vote against a devaluation. This level of disagreement could explain why politicians choose to implement devaluations after elections, as documented by Cermeño et al. (2010).

Related Literature

This paper is closely related to the quantitative literature that studies the redistributive effects of monetary policy. It also builds upon the literature on the relationship between wage rigidities and employment.

The redistributive effects of monetary policy have gained attention recently. For example, Auclert (2015) studies the redistributive effect of changes in the real interest rate via an interest rate exposure channel. Albanesi (2007) and Erosa and Ventura (2002) study the impact of inflation episodes on the wealth distribution when there is heterogeneity in cash holdings across the population. Similarly, Doepke and Schneider (2006), Meh et al. (2010) and Sterk and Tenreyro (2013) analyze the consequences of an unexpected inflation shock that redistributes from lenders to borrowers. Gornemann et al. (2014) analyze the heterogeneous gains in consumption and welfare after monetary policy shocks, paying attention to differences in the main source of income across households. Their main finding is that wealth-rich households gain when interest rate raises (since most of their income comes from returns on financial assets), and wealth-poor households lose from a higher unemployment rate (since most of their income comes from labor income). To the best of my knowledge, there are no papers that connect the redistributive effects of monetary policy with asymmetries in the labor market. This paper studies the distributive effects of a nominal devaluation that arise due to heterogeneities in the labor market. In addition, I also analyze the scenario in which the devaluation has an effect on the real value of assets. This allows me to study the interaction between the labor market effects and the wealth effects and see whether trade-offs arise for different types of workers.

In a closely related paper, Schmitt-Grohé and Uribe (forthcoming) study the relationship between currency pegs and downward nominal wage rigidities, and how they affect employment during recessions. Their analysis is based on a small open economy model populated by a representative household that supplies labor inelastically. The aggregate wage is subject to downward nominal wage rigidities. Their main finding is that currency pegs are highly costly in terms of unemployment and welfare.\footnote{Eichengreen and Sachs (1985) and Bernanke and Carey (1996) analyze the Great Depression and conclude that a major cause of the Depression was the combination of a fixed exchange rate regime and nominal wage stickiness. The effects of downward nominal wage rigidities are also documented in Calvo et al. (2013). In that paper, the authors analyze a sample of 116 recession episodes in developed and emerging market economies to compare the labor-market recovery during crises. They find that recessions with low inflation} By studying the effects of exchange rate policies in a
model with heterogeneous degrees of nominal wage rigidities and a rich set of heterogeneous agents, my analysis unmasks distinct welfare consequences of these policies on different groups of the population. Nonetheless, their model includes aggregate shocks, which allows them to find a connection between aggregate volatility and the average level of unemployment. This relationship opens the door to large welfare gains from stabilization policy via the exchange rate.

There are additional channels through which nominal devaluations have distributive consequences. In a recent paper, Cravino and Levchenko (2015) study the redistributive effects of changes in relative prices after nominal devaluations. Their starting point of analysis is the fact that households at different income levels consume very different baskets of goods, with low-income households consuming more tradable goods and high-income households consuming more non-tradable goods, and that nominal devaluations have a strong effect on relative prices. Using data from Mexico, the authors find that during the 1994 devaluation households in the lowest quintile of the income distribution experienced an increase in the cost of living of up to 1.6 higher than the household in the top quintile. These effects are complementary to the ones analyzed in this paper and, insofar the labor market effects are heterogeneous across the distribution of household income, it would be interesting to study the interactions between them.

One of the key ingredients of the model is heterogeneity in the degree of downward nominal wage rigidities across labor markets. The fact that aggregate nominal wages are rigid, in particular downwardly rigid, has been extensively documented. For example, Gottschalk (2005) finds using data from the PSID that in the US only 4-5% of hourly workers experience a decline in nominal wages over a period of a year. There is less evidence about how extensive these rigidities are within a country. In this paper, I document the heterogeneity in the degree of nominal wage rigidities across sectors in Argentina. I also show how this heterogeneity are associated with jobless recoveries, while episodes with high inflation are associated with a faster decrease in the unemployment rate and a slower recovery of wages.


5 There are few papers that compare the degree of nominal wage rigidities across countries. For example, Schmitt-Grohé and Uribe (forthcoming) analyze the wage growth in twelve European countries during the great recession of 2008. They show that although the unemployment rate increased substantially in all countries, nominal wages increased in most countries (and in those in which they decrease, the decline was small). Dickens et al. (2007) provide a more comprehensive analysis using micro-data from 16 countries and 360 dataset-years. They construct a measure of the extent of downward nominal wage rigidity by using the observed deviations from symmetry in the wage change distribution. The main finding is that nearly all countries show asymmetry in their wage change distributions, in particular, a high incidence of wage freezes and a lack of nominal wage cuts. Interestingly, this effect is quite heterogeneous across countries, which ranges from 4 percent in Ireland to 58 percent in Portugal.
manifests itself in other labor market variables and present evidence about the timing of union bargaining that support the hypothesis that unions play a role in affecting the flexibility of nominal wages. The role of unions in generating nominal wage rigidities has been documented by Fortin (1996) and Card (1990) using contract-level data from Canada.

This paper is also related to a large literature on the relationship between wage and employment dynamics (see, for example, Christiano et al. (2005), Costain and Reiter (2008), Gertler and Trigari (2009), Hall (2005), Michaillat (2012), Shimer (2005) and Smets and Wouters (2007)). One of the main conclusions that these papers reach is that in order to reconcile the evolution of unemployment during the business cycle some degree of wage rigidity is required. The contribution of this paper to this literature is the inclusion of different sectors with heterogeneous degrees of wage rigidities that allow me to understand the role of more flexible sectors during recessions. Also, the focus of this paper is on nominal rigidities as opposed to real wage rigidities.

Finally, a very large literature studies the role of informal labor markets in emerging market economies. This literature focuses on the benefits and costs that make workers and firms to operate in formal or an informal market. The benefits of operating in the informal sector are related to evasion of labor costs and taxes. The costs are associated with the fine the firm has to pay in case it is discovered operating informally by the tax authority. Recent quantitative papers of the impact these policies have on the labor market include: Albrecht et al. (2009), Bosch and Esteban-Pretel (2012), Meghir et al. (2015), Ulyssea (2010). My model abstracts away from these considerations and takes the existence of both sectors as given. However, it does take into account the fact that by operating formally firms must comply with the outcomes of the wage bargaining process with the union. The model also considers the observed heterogeneity in downward nominal wage rigidities across sectors.

Layout

The remaining of the paper is organized as follows. Section 2 presents motivational empirical evidence. Section 3 presents the model, defines the equilibrium in the economy and discusses the main assumptions. Sections 4 estimates the model using data from Argentina and describes the goodness of fit of the model with respect to the data. Section 5 provides counterfactual exercises designed to show the effects of a nominal exchange rate devaluation. Finally, section 6 concludes.

2. Motivating Empirical Facts

The empirical evidence that motivates the subsequent analysis focuses on an episode in which an economy went through a recession, kept the exchange rate fixed for some time, and eventually devalued the currency: Argentina between 1995 and 2011. The reason why
this experience is interesting is that Argentina, like many countries in Latin American and southern Europe, has a large informal labor market. In contrast to wages paid in the informal labor market, wages paid in the formal sector are subject to a centralized bargaining process between unions and firms. From now on I label all informal workers as competitive and all formal workers as unionized workers. I provide further support for this assumption in section 4 when describing the data in greater detail. The data used to motivate this paper come from the Argentinian household survey and national accounts, and are described in detail in Appendix C.1.

2.1. Evidence on Heterogeneity in Nominal Wage Rigidities

Panel (a) of Figure (1) displays the evolution of the (log) real GDP and the Argentinian peso (AR$) to US dollar nominal exchange rate during the 1995-2011 period. The stability brought by the Convertibility Plan, which pegged the Argentinian peso to the US dollar, led to a period of stability until 1998, before collapsing in 2002. The crisis ended with the peg in the exchange rate, and the nominal currency was devalued by more than 200% in a year. Arguably, the main sources of the recession were the previous crisis of other emerging markets that raised the borrowing costs in those markets (in particular, the Russian crisis), a large shock to the terms of trade and the devaluation of Brazil, one of the largest trade partners of Argentina.

Panels (b) and (c) show the evolution of the average nominal and real (log) hourly wages paid in the unionized and competitive sectors, respectively. One would expect that the severe recession put downward pressure on nominal wages. However, while nominal wages in the competitive sector did indeed decrease by 10.6% since the peak in 1998 and by an additional 10.3% at the trough of the recession, nominal wages paid in the unionized sector remained virtually constant. Despite the fact that wages might have been nominally rigid, real wages did decrease after the nominal devaluation. Interestingly, while real wages paid in the unionized sector recovered to the pre-recession levels in 3.5 years, real wages in the competitive sector remained at very low levels for an extended period of time. In Appendix A.1 I show that the heterogeneity in downward nominal wages is not driven by compositional effects. In particular, I show that the evolution of nominal and real wages presented here mimics the

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6 See Chen et al. (2002), Gasparini and Tornarolli (2009) and Hazans (2011) for a comparison of informality rates across countries. While it is indeed the case that informal labor is more prevalent in developing countries, the empirical evidence shows that informality is also large in southern Europe.

7 These facts differ from those presented by Kaur (2014). The author tests for downward nominal wage rigidities in informal markets for daily agricultural labor in India. She analyzes wage and employment responses to rainfall shocks and finds that nominal wage adjustment is asymmetric. Nominal wages rise in response to positive shock but do not decrease during droughts.
Figure 1. GDP, Wages and Labor Market in Argentina, 1995-2011

Notes: Panel (A): Deviation of quarterly real GDP from (log) trend (HP filter trend) and nominal exchange rate of the peso with respect to the US dollar between 1995 and 2011. Shadow area denotes period with negative growth. Data source: National Accounts. Panel (B): average (log) nominal hourly wage in main occupation. Panel (C): average (log) real hourly wage in main occupation. Panel (D): workers in each labor market states as a fraction of total population. Data source: Argentinian Household Survey. The sample includes all male and female workers between 25 and 60 years old. See Appendix C.1 for details. Series constructed using seasonally adjusted quarterly data. Missing values have been imputed with ARIMA model.

The evolution of wages once observed heterogeneity is taken into account by regressing (log) nominal and real wages on a set of controls (age, gender, education, tenure and industry) and time dummies.

One could argue that nominal rigidities might arise due to reasons unrelated to the existence of unions. In order to provide support for the hypothesis that unions play a central role, I collected data about all the contracts bargained between unions and firms in 12 sectors between 1995 and 2008. The results reported in Appendix A.2 show that in the years that led to the recession the overall number of new contracts signed was small (in some sectors there were none).\footnote{Before 2002, the Argentinian law allowed expired contracts to remain valid until a new contract was signed by the union and the firms. The result of this law was that during the 1990s a large proportion of the wages} The number of new contracts (especially those signed at the industry level, which
have the largest coverage) increases right after inflation started to increase due to the nominal devaluation. This fact explains the relatively constant average wage of formal workers during the recession period observed in the micro-data.\footnote{The evidence presented here is consistent with the evidence shown in Holden and Wulfsberg (2009). In that paper, the authors document that downward nominal rigidity is in general much more significant and of greater magnitude than the downward rigidity of real wages. They also find that the degree of downward real rigidity is positively associated with union density. This finding is consistent with the fact that in the Argentinian episode union real wages recovered much faster than competitive real wages.}

The evolution of the labor market is presented in Panel (d) of Figure (1). At the trough of the recession, 16% of the total population between 25 to 60 years old were unemployed. Although competitive employment decreased from 19.5% to 17% in 2002, employment in the unionized was more affected with a decline from 41.4% to 36.5%. Consistent with the evolution of real wages, the recovery of competitive employment was faster during the recovery part of the recession. The effects of heterogeneity in the degree of nominal wage rigidity can be also seen in Figure 2, which shows total competitive employment as a fraction of total employment. If the recession had a similar effect on the aggregate demand of goods produced in both sectors and if the nominal wages were equally rigid, one would expect that the composition of the labor market would have remained unaffected during the recession. However, the composition changed in favor of the competitive labor market throughout the crisis period.\footnote{It has been argued that informal employment has a stabilizing role for aggregate employment over the business cycle. For example, Fernández and Meza (2015) document the relationship between informal employment and the business cycle in Mexico. They document that informal employment is countercyclical and negatively correlated with formal employment. Further evidence of the flexibility of informal markets is provided by Arias and Escudero (2007) using data from the Argentinian household survey and applying a cohorts panel VAR approach.}

2.2. Worker Flows

Another piece of evidence that motivates my subsequent analysis are the transition rates of workers across labor market states. Figure 3 shows the one-year ahead transition rates out of the unionized sector, the competitive sector, non-participation and unemployment, respectively. First, the figures show that these labor markets are quite interconnected. Given that in the pre-recession period the annual transition rates across the competitive and unionized sectors are 6% and 20%, respectively, the view of these labor markets as being fully segmented is not appropriate. Panel (a) shows that the probability of making the transition from the unionized to the competitive sector remains quite stable throughout the recession and then decreases due to the recovery of the economy. More interestingly, Panel (b) shows that the probability of transitioning out of the competitive to the unionized sector is countercyclical (it goes from 22% to 13% at the trough of the crisis, before recovering back to the pre-recession level). The graph also shows that this decrease is almost compensated by an equal increase in
Figure 2. Fraction of Workers Employed in the Competitive Sector

Notes: This figure plots the fraction of workers employed in the competitive sector computed as the number of competitive workers over total employment. Data source: Argentinian Household Survey. The sample includes all male and female workers between 25 and 60 years old. See Appendix C.1 for details. Series constructed using seasonally adjusted quarterly data. Missing values have been imputed with ARIMA model.

the probability of making the transition from the competitive sector into unemployment. This suggests that during the recession there was a fraction of workers that in normal times would have successfully made a transition into the unionized sector, but ended up unemployed.

This evidence is the flip side of the differences in the degree of flexibility to decreases in nominal wages. Since wages in the unionized sector fail to decrease, the lower aggregate demand forces firms to reduce employment. Laid-off workers have the option to search for jobs in the competitive sector or remain non-employed/unemployed waiting until they find a job again in the same sector. In reality, both types of decisions are made. On the other hand, workers in the competitive sector find it harder to find a job in the unionized sector. So they have the option to remain employed in the same sector at a decreasing wage throughout the recession or to become non-employed/unemployed.

Finally, Panels (c) and Panels (d) show the transition rates out of non-employment and out of unemployment, respectively. Again, the evidence shows that the transition rate towards the competitive labor market remained unaffected by the recession. Once the recession is over, the transition towards both employment states increases, with the increase towards the competitive sector being substantially larger.
Figure 3. Gross Flow Rates across States and Composition of the Labor Market

Notes: This figure plots the average probabilities of transitioning from any labor market states within a period of a year. Each panel corresponds to a state of origin and the series contained correspond to a state of destination (the fraction of workers that do not change their state is omitted). Data source: Argentinian Household Survey. The sample includes all male and female workers between 25 and 60 years old. See Appendix C.1 for details. Series constructed using seasonally adjusted quarterly data. Missing values have been imputed with ARIMA model.

3. The Model

In this section, I develop a quantitative model that is estimated and used to carry out counterfactual analysis. The model is a small open economy with two new features. First, I model two sectors that react differently to aggregate shocks and monetary policy due to different institutional features of the labor market in which they operate. Second, heterogeneous risk averse workers choose whether to participate in the labor market or not and, conditional on participation, in which sector to supply their labor.

The economy is populated by heterogeneous workers, a single capitalist, intermediate and final goods producers and a government. Workers supply labor to the firms and make consumption and savings decisions. Labor is assumed to be imperfectly mobile across sectors, but workers are forced to supply their units of labor services to a single sector at any given point in time. Furthermore, labor markets are subject to search frictions. Once workers make
their labor supply decision and their labor market status are determined, they consume and save. They have access to international capital markets and can lend freely at an exogenous real interest rate. The capitalist is the sole owner of all the firms in the economy. In each period, he receives all the profits from the firms and makes consumption and savings decisions (he does not supply labor to the firms).

There are three representative firms that produce intermediate goods. One produces the intermediate tradable good, and the other two produce intermediate non-tradable goods. In each period, a firm inherits a level of capital from past investment, rents labor services from workers to produce the good and makes investment decisions to affect the stock of capital in the next period. The feature that distinguishes firms producing the non-tradable good is the institutional characteristic of the labor market in which they operate. In one of the sectors, the unionized, wages are determined jointly between unions and firms and are subject to downward nominal wage rigidities. In the other, the competitive one, wages are determined in a competitive way. Final goods producers combine varieties produced in the unionized and competitive sectors in order to produce the final non-tradable good. Finally, the government collects taxes from labor income, makes transfers to all non-employed workers and pays interest on government debt. To summarize, there are three productive sectors in total: \((T)\) tradable, \((NU)\) non-tradable unionized and \((NC)\) non-tradable competitive. There is a fourth sector \((0)\), the non-employment sector, which can be interpreted as the “unemployment” or “out of the labor force” sector, depending on whether the worker is actually searching for a job or not.

The model is used to analyze the effects of heterogeneous degrees of downward nominal wage rigidities and the impact devaluations have during recessions. The analysis begins with the steady state of the model in which agents expect that the economy will remain in steady state and that the government will keep the exchange rate fixed. In period one, there is an unanticipated negative shock to TFP in the tradable sector. Several possible scenarios are considered here. In the first, the government decides to maintain the exchange rate fixed. In the other, it implements an unanticipated and permanent nominal exchange rate devaluation. These shocks induce the economy to undergo a deterministic transition path back to the original steady state (in terms of real allocations). In order to simplify notation, all the information that economic agents need to know to make their optimal decisions is condensed in the time subscript \(t\). Next I describe the problem that each agent faces, define the competitive equilibrium of this economy, discuss the main assumptions made in the model and briefly describe the numerical algorithm used to solve the model.
Workers

There is a continuum of workers indexed by $i \in [0, 1]$, who face a constant probability of dying equal to $\gamma \in (0, 1)$.$^{11}$ Workers have preferences over consumption and leisure

$$\sum_{t=0}^{\infty} \beta^t \mathbb{E}[u(C_{it}) + \sum_s \epsilon_{it} \mathbb{1}\{d_{it}^s = 1\} - \nu \mathbb{1}\{d_{it}^0 \neq 1\}]$$

(1)

with per-period utility of consumption given by

$$u(C_{it}) = \frac{C_{it}^{1-1/\sigma}}{1-1/\sigma}, \quad C_{it} = \left(\zeta C_{it}^{\xi} + (1 - \zeta) N_{it}^{\xi} \right)^{\frac{1}{\xi}}.$$  

(2)

where $C_{it}^T$ and $C_{it}^N$ denote the consumption of tradable and non-tradable goods, respectively. The parameter $\xi$ is the elasticity of substitution between these two goods, $\sigma$ denotes the elasticity of inter-temporal substitution and $\beta$ is the subjective discount factor. The labor supply decision is captured by the indicator $d_{it}^s$ that is equal to one if the worker decides to search for a job in sector $s \in \{T, NU, NC\}$ or to remain non-employed ($s = 0$). Labor supply choices are subject to iid preference shocks denoted by $\epsilon_{it}$. These shocks are independently and identically distributed over time, workers and sectors. These shocks capture any element that affects sectoral choice that is uncorrelated with sectoral characteristics, nor with worker and sector-specific wages (e.g. availability of a job in a specific location). The main purpose of these shocks is to generate gross flows in excess of net flows, which is a feature of the data. In order to participate in the labor market the worker must pay a fixed cost $\nu$ expressed in terms of utils.

Workers have idiosyncratic shocks to labor productivity. This productivity is assumed to follow the stationary process:

$$\log z_{it} = \rho_z \log z_{it-1} + \varepsilon_{it},$$

(3)

where the $\varepsilon_{it}$ is distributed $N(0, \sigma_z^2)$. Thus, if a worker is employed in sector $s$ he supplies $z_{it}$ units of efficiency labor and earns $w^s_{it} z_{it}$ in labor income. I further assume that workers are not able to borrow and that there are no insurance markets for idiosyncratic risk. However, workers can accumulate one-period bonds that pay an exogenous interest rate $R$ (with $\beta(1 + R) = 1$). In the baseline analysis, these bonds are denominated in foreign currency. However, I also analyze the effects of a devaluation when a fraction of these bonds are denominated in local currency. Labor income is taxed at rate $\tau^s$ by the government in order to finance a lump-sum

---

$^{11}$Upon the dead of a worker, he consumes all his savings and gives birth to a new worker with zero assets, labor productivity equal to the mean productivity and previous sector of employment drawn from the distribution of previous sector of employment from the previous period (the role of this last state variable is described below). The reason for assuming that dead workers consume all his savings is to generate a sizable number of workers with zero savings.
transfer to non-employed workers. The worker makes consumption, labor supply and savings decisions to maximize lifetime utility (1) subject to the period budget constraint

\[ P_t^T C_{it}^T + P_t^N C_{it}^N + \frac{E_t b_{it+1}}{1 + R} \leq \sum_{s \neq 0} (1 - \tau^s) w_i^s z_{it} d_{it}^s + T_i d_{it}^0 + E_t b_{it} \]

and the borrowing constraint

\[ b_{it+1} \geq 0, \]

where \( P_t^T \) and \( P_t^N \) denote the prices of the tradable and non-tradable final good respectively, \( E_t \) is the nominal exchange rate, \( b_{it+1} \) denotes the purchase of one-period bonds that mature in period \( t+1 \) and \( T_i \) is the government transfer received in case of being non-employed. While \( \hat{d}_{it}^s \) denotes the labor supply choice made by the worker, \( d_{it}^s \in \{0, 1\} \) denotes the actual labor market status of worker \( i \) in period \( t \). Due to labor market frictions that will be explained in more detail below, workers might not immediately find a job in the sector of their choice.

The model features frictions that influence the rate at which workers lose their jobs, find new jobs and transition across sectors. In particular there are two types of labor market frictions: standard search frictions (as in Pissarides (1990)) and job rationing frictions (as in Michaillat (2012)).

Conditional on being non-employed at period \( t-1 \) and having been previously employed in sector \( s_{i-1} \), with probability \( \lambda^{s_{i-1}} \) workers can search for a job in sector \( s_{i-1} \) only and with probability \( 1 - \lambda^{s_{i-1}} \) workers can search for a job in any sector.\(^\text{13}\) While searching for a job in sector \( s' \) at period \( t \), the worker receives news about a job opportunity with probability \( n^{0,s'} \) and sends a job application. Similarly, workers employed in sector \( s \) at period \( t-1 \) exogenously receive news about a job opportunity in sector \( s' \) in period \( t \) with probability \( n^{s,s'} \) and are given the choice to make a job-to-job transition. Given this opportunity, they can decide to apply for a job in the same sector of previous employment, apply for a job in the sector from which they received news or to become non-employed. Thus, the model allows for job-to-job transitions with exogenous probabilities that depend on the sector of origin and the sector of destination. This feature of the model makes some transitions across sectors more likely to occur, which is a feature of the data (for example, it is more likely to transition to the unionized sector from the competitive sector than from non-employment). Altogether,

\(^\text{12}\) The tax rate is allowed to differ across sectors of employment to reflect the fact that in the data unionized workers are formally hired (and therefore pay taxes) and competitive workers are informally hired (and therefore do not pay taxes).

\(^\text{13}\) The reason for introducing this friction is that in the data many workers return to the sector of previous employment after an unemployment spell. Since in the model there are no other worker’s characteristics that would induce this behavior, this observation is achieved in this simple way.
these probabilities reflect the fact that it takes time to hear about the availability of a job of interest (i.e., standard search frictions).

Once the worker submits the job application, the probability $q_{it}^{s,s'}$ that the application is accepted and the worker gets the job depends on the labor market in which the worker is searching for a job. If sector $s'$ belongs to a competitive sector, then the application is accepted with time-invariant probability equal to one ($q_{it}^{s',s'} = 1$ for $s' = \{NC\}$). If sector $s'$ belongs to an unionized sector, then the application might be accepted with a probability smaller than one. This probability is the source of the job rationing friction and is determined endogenously. However, it might be the case that the compensation offered in these sectors is attractive enough so that workers are willing to end up non-employed with some probability. These probabilities are determined during the wage setting process.

The previous frictions are embedded in the model in the following way. At the beginning of period $t$ workers observe the realization of their idiosyncratic productivity shocks. If at period $t - 1$ the worker was employed in sector $s$, with probability $\psi^s$ he receives an iid separation shock at period $t$ which makes him lose his current job and remain non-employed for the rest of the period. With probability $1 - \psi^s$ he is not separated and has the opportunity to choose between working in the same sector of previous employment, apply for a job in another sector (in case he is given the opportunity) or become non-employed. If at period $t - 1$ the worker was non-employed, at period $t$ he can choose whether to remain non-employed or search for jobs in any sector with probability of receiving news about a job opportunity equal to $n_0^{s,s'}$. As mentioned before, the sectoral choice is subject to preference shocks $\epsilon^s_{it}$ to the value of choosing sector $s$. The following timeline describes the timing of the worker’s choices

<table>
<thead>
<tr>
<th>($z_{it}, b_{it}, s_{it}$)</th>
<th>Savings and consumption choice</th>
<th>Death shock $z_{i,t+1}$ shock</th>
<th>Separation shock $s_{i,t+1}$ choice</th>
<th>Arrival of job news</th>
<th>Approval of job applications</th>
<th>($z_{it+1}, b_{it+1}, s_{it+1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t = 0$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$t = 1$</td>
</tr>
</tbody>
</table>
Capitalist

I assume that an infinitely-lived capitalist is the sole owner of all the firms in this economy and that firms’ profits accrue to him only.\(^{15}\) After receiving firms’ profits, the capitalist makes consumptions and savings decisions (he does not supply labor to the firms) to maximize lifetime utility. Thus, the problem of the capitalist is to maximize

\[
\max_{\{C_{kt}, C_{kt}^N, b_{kt+1}\}} \sum_{t=0}^{\infty} \beta^t u(C_{kt})
\]

subject to

\[
P_t^T C_{kt} + P_t^N C_{kt}^N + \frac{E_t b_{kt+1}}{1 + R} + E_t g(b_{kt+1}) \leq \sum_{s \neq 0} \Pi_s^t + E_t b_{kt},
\]

where \(\Pi_s^t\) denotes profits from sector \(s\) and the per period utility of consumption is given by (2). The function \(g(b_{kt+1})\) denotes a convex adjustment cost of bonds.\(^{16}\)

Production of Final Goods

Final goods are produced by a perfectly competitive, representative firm that takes the output and input prices as given. The final non-tradable good is produced by combining differentiated intermediate goods produced in the unionized and competitive sub-sectors. The production function of final goods is given by

\[
Y_t = \left( \frac{\mu_N}{\nu N} (Y_t^{NU}) \right)^{\frac{\nu - 1}{\nu}} + (1 - \mu_N)^{1/\nu} \left( Y_t^{NC} \right)^{\frac{\nu - 1}{\nu}},
\]

where \(\nu\) is the elasticity of substitution across goods produced in the unionized and competitive sub-sectors. The demands of both goods are determined by profit maximization of the final good producer and are characterized by

\[
Y_t^{NU} = \left( \frac{P_t^{NU}}{P_t^{NC}} \right)^{\nu} Y_t^{N} \mu_N \quad \quad Y_t^{NC} = \left( \frac{P_t^{NU}}{P_t^{NC}} \right)^{\nu} Y_t^{N} (1 - \mu_N),
\]

where the price index \(P_t^{NT}\) is given by

\[
P_t^{NU} \equiv \left( \mu_N \left( P_t^{NU} \right)^{1-\nu} + (1 - \mu_N) \left( P_t^{NC} \right)^{1-\nu} \right)^{1/(1-\nu)}.
\]

\(^{15}\) This is a reasonable assumption in Argentina, where 84% of total capital income, rents and profits are received by households in the highest quintile of the household income distribution (De Ferranti et al. (2004)).

\(^{16}\) Given the small open economy assumption, the real interest rate is exogenous and the level of capitalist’s assets is not uniquely characterized in steady state. In order to induce stationarity I follow Schmitt-Grohé and Uribe (2003) and assume that the capitalist faces convex costs of holding quantities of bonds different than a long-run level given by \(\bar{b}\), which are represented by

\[
g(b_{kt+1}) = \frac{g}{2} (b_{kt+1} - \bar{b})^2.
\]

Given the assumption that \(\beta(1 + R) = 1\), the inclusion of these costs pin down the level of bonds in steady state to \(\bar{b}\).
Regarding the final tradable good I assume that the law of one price holds, so that the local price of the tradable good equals the foreign-currency price expressed in local currency $P_t^T = P_t^{T*}E_t$. The foreign-currency price $P_t^{T*}$ is normalized to unity.

**Production of Intermediate Goods**

Each intermediate good is produced by a representative firm operating in each sub-sector $s \in \{T, NU, NC\}$ that combines capital and labor according to the following Cobb-Douglas production function

$$Y_t^s = A_t^s (H_t^s)^{\alpha^s} (K_t^s)^{\theta^s},$$

where $H_t^s$ represents the aggregate labor used in sector $s$ in period $t$ measured in units of efficiency labor services, $K_t^s$ is the amount of capital obtained from past investment at $t - 1$ and available for production in period $t$, $A_t^s$ is a productivity shock, $\alpha^s$ and $\theta^s$ are parameters.

While the demand for labor is allowed to adjust freely, investment in capital is subject to adjustment costs. The amount of capital available for production at period $t + 1$ in sector $s$, and determined at period $t$, is given by

$$K_{t+1}^s = (1 - \delta) K_t^s + I_t^s - \Phi (K_t^s, K_{t+1}^s),$$

where $\delta \in (0, 1)$ denotes the capital depreciation rate and $\Phi (\cdot)$ denotes capital convex adjustment costs represented by

$$\Phi (K_t^s, K_{t+1}^s) = \frac{\Phi}{2} \left( \frac{K_{t+1}^s}{K_t^s} - 1 \right)^2 K_t^s.$$

It is assumed that capital $K_t^s$ is a composite of tradable and non-tradable capital, which are aggregated according to the same CES aggregator with which consumers aggregate tradable and non-tradable consumption. The objective of the firm is to maximize the discounted present value of the stream of real profits

$$\sum_{t=0}^{\infty} \Lambda_{0,t} \Pi (H_t^s, K_t^s, K_{t+1}^s) = \sum_{t=0}^{\infty} \Lambda_{0,t} P_t [P_t^s Y_t^s (H_t^s, K_t^s) - w_t^s H_t^s - P_t I_t^s],$$

where $\Lambda_{t,t+j}$ is the firm’s discount factor, $w_t^s$ is the nominal wage per unit of efficiency of labor and $P_t$ is the aggregate price index of the consumption bundle. Taking input and good prices as given, the firm’s optimal input demands are characterized by the following first order conditions

$$\left( 1 + \Phi_{K_{t+1}^s} (K_t^s, K_{t+1}^s) \right) = \frac{\Lambda_{t+1}}{P_{t+1}} \left( P_{t+1} \frac{\partial Y_{t+1}^s (H_{t+1}^s, K_{t+1}^s)}{\partial K_{t+1}^s} + P_{t+1} \left( 1 - \delta + \Phi_{K_{t+1}^s} (K_{t+1}^s, K_{t+2}^s) \right) \right),$$

and
\[ w_t^s = P_t^s \frac{\partial Y_t^s (H_t^s, K_t^s)}{\partial H_t^s}. \]

Some additional assumptions are in order. First, I assume that \( \alpha^s + \theta^s \leq 1 \), with strict inequality for \( s \in \{ T, NU \} \). As a consequence of this assumption, firms will earn strictly positive rents, and firms and unions bargain over these. Second, entry into and exit out of production of intermediate goods are ruled out.

**Wage Setting**

The wage rate per efficiency unit of labor employed in the competitive sub-sector is assumed to be determined in a competitive way. That is, wages paid in these sectors are the ones that equalize the workers’ aggregate supply of labor services with the firm’s demand. Furthermore, the labor market that operates in this sector is not subject to any nominal rigidity.

Contrary to the wage setting mechanism of the competitive labor market, sectoral wages per efficiency unit of labor services employed in the unionized sectors are determined through a process of collective bargaining. Specifically, I assume that there is a single trade union that negotiates the wage per efficiency unit of labor with the intermediate producer in sector \( s \) for all workers employed in the sector.\(^{17}\) The negotiated contract specifies a nominal wage per unit of efficient labor that remains fixed for a single period, after which a new negotiation will take place. Once the bargaining process is over, the firm chooses freely the level of labor and capital that maximizes profits taking the bargained wage as given (in the literature this bargaining model has been known as the *right-to-manage* model).

The preferences of the union are assumed to depend on the after tax real wage paid in sector \( s \) and the level of aggregate labor employed relative to the aggregate labor supply,\(^{18}\) and can be represented by

\[
\sum_{t=0}^{\infty} \beta^t \left( \frac{w_t^s (1 - \tau)}{P_t} \int q_{it}^{s, s'} q_{it}^{s', s} z_{it} \, di + \frac{T_t}{P_t} \int d_{it}^{s, s'} \left( 1 - q_{it}^{s, s'} \right) \, di \right),
\]

\(^{17}\)The literature that studies the behavior of trade unions has previously made the distinction between workers that are members of the trade union and workers that are not (for a recent example, see Cole and Ohanian (2004)). However, given the features of the labor market analyzed in the empirical section of this paper and of many labor markets in European countries, this assumption is more realistic. In all of these cases, the outcomes of the bargaining process apply to all workers covered by the contract, irrespective of the membership status of each worker. See Hayter and Stoevska (2008) for country-level statistics about union membership and coverage rates.

\(^{18}\)In other words, the union has preferences over the total wage bill. Earlier work on the estimation of unions’ objectives considered these preferences (see, for example, MacCurdy and Pencavel (1986), Pencavel (1984)). Similar preferences are assumed by Blanchard and Giavazzi (2003), Calvo (1978), Gersbach and Schniewind (2011), Lippi (2003), Krusell and Rudanko (2012), Mattesini and Rossi (2009), Rosen (1970) and Zanetti (2007).
where \( d_{it}^{s,s'} \) is equal to one if worker \( i \) was in sector \( s \) in period \( t - 1 \), received news about a job opportunity in sector \( s' \) in period \( t \) and submitted an application, and \( q_{it}^{s,s'} \) is the probability that the application is accepted (defined below). The union discounts the future at the rate \( \beta \). Thus, the union is benevolent in the sense that it maximizes the income of all workers that apply for a job in the sector. These preference and the value of the firm can be represented recursively by the following value functions

\[
U_s^t (w_{t-1}^s, K_s^t) = \frac{w_t^s(1-\tau)}{P_t} \int d_{it}^{s,s'} q_{it}^{s,s'} z_{it} di + \frac{T_t}{P_t} \int d_{it}^{s,s'} \left(1 - q_{it}^{s,s'}\right) di + \beta U_{t+1}^s (w_t^s, K_{t+1}^s)
\]

\[
F_s^t (w_{t-1}^s, K_s^t) = \max_{H_t^s,K_{t+1}^s} \frac{P_t Y_t^s (H_t^s, K_t^s) - w_t^s H_t^s - P_t I_t^s}{P_t} + \Lambda_{t+1} F_{t+1}^s (w_t^s, K_{t+1}^s)
\]

subject to

\[
H_t^s \leq \int d_{it}^{s,s'} q_{it}^{s,s'} z_{it} di.
\]

The first equation represents the value function of the union in sector \( s \) at period \( t \), which depends on the nominal wage paid in period \( t - 1 \) and the current level of capital in that sector. This value function equals the current utility of the union (given by the sum between total real labor income received by employed workers and total real transfers received by unemployed workers) and the continuation value. The second value function corresponds to the firm, and is equal to maximized current real profits and the firm’s continuation value. The last inequality imposes a constraint in the firm’s labor demand given by the amount of labor supplied by workers in the current period.

In each period \( t \) the trade union and the firm negotiate over the wage per efficiency unit of labor. This bargaining problem is modeled through a Nash bargaining process, in which the bargained wage is the outcome of a maximization problem of the geometric average of the firm’s and union’s net surplus from reaching an agreement, in which the weights represent each side’s bargaining strength. The solution to the bargaining problem requires specifying the bargaining parties’ outside options. I assume that in case the parties do not reach an agreement in period \( t \) no production occurs during the period. However, in this scenario, firms would still be able to make investment decisions to change the level of capital available in the next period and workers would remain unemployed and receive the government transfer as their only source of income. Also, in period \( t + 1 \) bargaining would resume with a wage floor equal to \( w_{t-1}^s \). Given these assumptions, the surpluses of the union and the firm are given by
The key friction that affects unionized labor markets is the prevalence of downward rigidities in nominal wages. There is no consensus in the literature about the way to introduce wage rigidities. For example, Blanchard and Galí (2010) and Michaillat (2012) assume that real wages partially adjust to technology shocks and exogenously impose a functional form for this partial adjustment. Gertler and Trigari (2009) modify the standard bargaining problem and introduce staggered multi-period wage contracting à la Calvo (1983). Hall (2005) introduces wage stickiness in the form of a wage norm. Following Schmitt-Grohé and Uribe (forthcoming), I assume that the bargaining process is subject to a nominal friction that prevents nominal wages from decreasing by more than a given percentage $\kappa$ relative to the prevailing wage at period $t-1$, but allows any nominal wage increases:

$$w_t^s \geq \kappa w_{t-1}^s.$$  

The bargaining outcome is given by the wage $w_t^s$ that solves the maximization problem

$$\max_{w_t^s \geq w_{t-1}^s} \left( \tilde{U}_t^s (w_{t-1}^s, K_t^s) \right) \eta^s \left( \tilde{F}_t^s (w_{t-1}^s, K_t^s) \right)^{1-\eta^s}$$

subject to the firm’s labor demand given by the solution of the firm’s problem (5).

Finally, in the unionized sub-sectors employment is demand-determined and wages do not adjust to clear the labor market. In other words, given the bargained nominal wage, the firm is able to freely demand the level of labor services that maximizes profits, up to a maximum level given by the aggregate labor supply to that sector in period $t$, which might be binding or not. When the constraint is not binding, not all workers looking for employment in these sectors are able to find a job. Therefore, a mechanism needs to be specified to ration scarce employment among individuals waiting for their job applications to be accepted. Here I make the assumption that workers that were previously employed in the sector have priority over entrants. Therefore, if the firm wants to decrease employment given the bargained wage the probability of new applications being approved decreases. If the desired fall in employment is large enough, then the firm does not hire new workers and also fires employed workers. On the contrary, if the firm wants to increase employment, all previously employed workers that
want to work get a job and the remaining jobs are distributed randomly among the workers that submitted an application and are trying to enter the sector. This assumption implies that the job rationing probabilities are given by

$$q^{s', s'}_t = \min \left\{ \frac{H_t^{s'}}{\int z_{it} d^{s', s'}_t \, di}, 1 \right\}$$ (8)

and

$$q^{s, s'}_t = \max \left\{ \min \left\{ \frac{H_t^{s'}}{\int z_{it} d^{s', s'}_t \, di}, 1 \right\}, 0 \right\}$$ (9)

for $$s' = \{ T, NU \}$$.

The Government’s Policy and Resource Constraint

The government is in charge of conducting fiscal policy. More specifically, the government collects income taxes from employed workers and makes lump-sum transfers to all workers that are not employed. The government has an initial level of assets $$b_{gt}$$ (which could be negative) that are denominated in foreign currency and pay the same exogenous real interest rate $$R$$. In the baseline specification of the model I abstract from government expenditure. However, this point will come back when analyzing counterfactual scenarios in which the government benefits from the revaluation of its debt and the gains have to be spent in some way. Thus, the government’s budget constraint in each period $$t$$ can be written as

$$\frac{E_t b_{gt+1}}{1 + R} + T_t d^0_{it} \, di = E_t b_{gt} + \int \sum_{s \neq 0} \tau^s w^s_{it} z_{it} d^s_{it} \, di.$$ (10)

For a given tax rate and a given path of government debt, the balanced budget constraint of the government implicitly defines a level of per capita transfers for each period $$t$$.

Finally, combining the budget constraint of all workers, the capitalist and the government, the aggregate resource constraint of the economy can be expressed as

$$P^T_t C^T_t + P^N_t C^N_t + \frac{E_t b_{lt+1}}{1 + R} + E_t g \left( b_{kt+1} - \bar{b} \right) + \sum_{s \neq 0} \left( P_t K^s_{kt+1} + P_t \Phi \left( K^s_t, K^s_{kt+1} \right) \right)$$

$$= \sum_{s \neq 0} \left( P^s_t Y^s_t + (1 - \delta) P_t K^s_t \right) + E_t b_t,$$

where $$C^T_t$$ and $$C^N_t$$ denote the aggregate level of consumption of tradable and non-tradable goods, respectively, and $$b_{lt+1}$$ denotes the aggregate level of bonds held by the capitalist, the government and the workers.
Discussion of Assumptions

In the first place, the union is assumed to maximize the total labor income of workers that end up employed in each sector. In other papers (as in Blanchard and Giavazzi (2003) and Taschereau-Dumouchel (2010)) these preferences of the union are derived from the aggregation of the utilities of the workers it represents. In order to achieve aggregation, these papers must either assume that workers are risk neutral or that workers are members of a representative household that allows for perfect consumption smoothing as in Rogerson (1988) and Hansen (1985). Here, the preferences of the union are assumed rather than derived from the workers’ preferences. The presence of risk-averse workers that are not able to pool idiosyncratic risk with the rest of the workers in the economy (and can only save to smooth consumption) prevents me from aggregating the preferences of workers that decide to supply their labor to an unionized sector in a parsimonious way. The alternative of specifying the union’s utility as the sum of workers’ preferences would make the computation of the equilibrium difficult.

The second assumption is also related to the bargaining problem. Nominal rigidities are incorporated with a simple reduced-form friction that prevents wages from decreasing by more than a gross fraction \( \kappa \) of to the wage paid in period \( t-1 \). Benassy (1995) shows that nominal wage rigidities can arise in a model in which rational trade unions negotiate the wage before knowing the realizations of all shocks (monetary and real) that could affect the economy and without being able to write wage contracts contingent on any possible realization of these shocks. In that model, although wage indexation is an option available to the union, it optimally choose not to index fully. Similarly, Holmes and Hutton (1996) provides a model of involuntary unemployment and sticky nominal wages that result from the inter-temporal optimization decision of monopsonistic firms which form rational expectations of the uncertain price they will receive for their product at the time they post wages. Given that my model does not have any aggregate uncertainty that would induce such nominal rigidities endogenously, these types of frictions are embedded in a tractable reduced-form restriction.

Finally, there are assumptions made regarding the competitive sector. In my empirical analysis, I use data from the informal sector and treat it as the competitive sector in the model. The literature that studies informal labor markets focuses on the workers’ and firms’ decision to operate in the formal and informal market. The traditional trade-off incorporated in those models is that firms have to pay taxes, social security contributions and severance payments after laying workers off in order to operate in the formal sector. Informal firms are not subject to these costs, but must pay a fine if they are randomly monitored by the fiscal authority. My model abstracts from the standard trade-off found in the literature. First, it takes the firm’s sectoral choice as given and considers only the worker’s decision to work in the formal (unionized) or informal (competitive) sector. Second, the model abstracts from the regulation that formal firms face (other than the labor income tax paid by formal workers

24
and used to finance the government transfer to the non-employed). However, despite the fact that some papers also recognize the fact that formal firms must comply with minimum wage regulations, few papers consider the fact that formal firms must also comply with the outcome of the bargaining process between unions and firms.\footnote{Exceptions include Agénor (2005), who theoretically studies the labor market effects of fiscal adjustment in an economy with an informal sector, minimum wages and an unionized labor in the formal economy, imperfect labor mobility, and public production of intermediate inputs.} Finally, for tractability purposes the model does not include a tradable competitive variety. In the data this group represents less than 2\% of the working population. Since the dynamics of the average wage and employment is quite similar to the dynamics found in the non-tradable competitive sector, the empirical analysis pools all competitive workers together.

**Competitive Equilibrium**

Having presented the model and discussed the main assumptions I define a competitive equilibrium in the following way

**Definition 1.** The equilibrium of this economy is defined by workers’ policy functions

\[
\{ \{ C^T_t (z_{it}, b_{it}, s_{i-1}, s_{it}), C^N_t (z_{it}, b_{it}, s_{i-1}, s_{it}), d^s_t (z_{it}, b_{it}, s_{i-1}, s_{it}), b_{t+1} (z_{it}, b_{it}, s_{i-1}, s_{it}) \} \}_{t=0}^\infty \}
\]

and value functions \[\{ \{ V^s (s_{-1}, z_{it}, b_{it}) \}_{t=0}^\infty \}_s\], capitalist’s policy functions

\[
\{ C^T_{kt} (b_{kt}), C^N_{kt} (b_{kt}), b_{kt+1} (b_{kt}) \}_{t=0}^\infty \]

firms’ policy functions \[\{ \{ H^s_t (K^s_t, w^s_{t-1}) , K^s_{t+1} (K^s_{t}, w^s_{t-1}) \} \}_{t=0}^\infty \}_s\], government’s policies \[\{ b_{gt}, T_t, E_t \}_{t=0}^\infty \], factor and goods prices \[\{ w^s_t, P^s_t \}_{t=0}^\infty \}_s\] and a sequence of distributions of workers such that for a given sequence of exogenous shocks \[\{ A_t \}_{t=0}^\infty \]:

1. \[\{ C^T_t (z_{it}, b_{it}, s_{i-1}, s_{it}), C^N_t (z_{it}, b_{it}, s_{i-1}, s_{it}), d^s_t (z_{it}, b_{it}, s_{i-1}, s_{it}), b_{t+1} (z_{it}, b_{it}, s_{i-1}, s_{it}) \} \}_{t=0}^\infty \]
   solves the individual worker’s problem and the value functions satisfy (11) and (12),

2. \[\{ C^T_{kt} (b_{kt}), C^N_{kt} (b_{kt}), b_{kt+1} (b_{kt}) \}_{t=0}^\infty \]
   solves the capitalist’s problem,

3. \[\{ \{ H^s_t (K^s_t, w^s_{t-1}) , K^s_{t+1} (K^s_{t}, w^s_{t-1}) \} \}_{t=0}^\infty \}_s\]
   solves the intermediate firm’s problem,

4. for \[s = \{ T, NU \}\], \[w^s_t\] is the outcome of the bargaining problem (7),

5. for \[s' = \{ NC \}\], \[w^{s'}_t\] is such that \[H^{s'}_t = \int d^{s'}_{it} d_i\],

6. the job rationing probabilities are given by (8) and (9),

7. the market for non-tradable goods clears: \[Y^N_t = C^N_t + I^N_t\],

8. the distribution of workers is consistent with individual behavior,
(9) and the government’s budget constraint (10) is satisfied in all periods.

Computing the Equilibrium

The aggregate state of the economy in period $t$ is given by $\Omega_t = (E_t, A_t, R_t, K_t, b_{gt}, b_{kt}, w_{T-1}, w_{NU-1}, x_t)$, where $E_t$ is the nominal exchange rate set by the government, $A_t$ is the productivity vector in the production of intermediate goods, $R_t$ is the exogenous real interest rate, $K_t$ is the vector of the stock capital available for each sector $s$, $b_{gt}$ is the level of assets of the government, $b_{kt}$ is the level of assets of the capitalist, $\{w_{T-1}, w_{NU-1}\}$ are the wage rates per efficiency unit of labor services paid in unionized sectors in period $t-1$ and $x_t$ is the distribution of workers across the individual state space in period $t$. The state space of the individual worker is given by $\Omega_{it} = (\Omega_t, b_{it}, z_{it}, s_{t-1}, s_{it})$, that is, the aggregate state space of the economy and the worker-specific level of assets, labor market productivity, past and current labor market status.

Due to the computational complexity of the problem given by the existence of infinitely many heterogeneous agents, I impose the assumption that all economic agents have perfect foresight about the future path of the vector $\Omega_t$. Since the goal of the paper is to analyze the effects of a nominal devaluation during a recession I solve the perfect foresight equilibrium transition path of an economy that at period $t = 0$ is at the steady state and in period $t = 1$ is unexpectedly hit by a mean reverting shock to tradable TFP. I use global numerical methods to solve for the transition paths. All dynamic problems are solved with standard numerical dynamic programming techniques (Judd (1998)). For a given parametrization of the model, the optimal policies and values are computed using a combination of policy and value function iteration. The equilibrium objects are computed via non-stochastic simulation of the workers distribution (Young (2010)) and fixed point iteration (Maliar et al. (2011)). A full description of the solution method is presented in Appendix B.

4. Estimation

Since the objective of the paper is to provide a quantitative analysis of the effects of exchange rate policy during a recession I need to set values to the parameters of the model that result in reliable quantitative predictions relative to the data. This section describes the main sources of data, the estimation strategy and its implementation, the selection of moments used during the estimation and discuss the identification of the model’s structural parameters.

4.1. Data

The main source of data is the Argentinian Permanent Household Survey (Encuesta Permanente de Hogares, EPH), a nationally representative survey of the urban population (around 85% of total population). Between 1995 and 2003 the survey was conducted twice a year and afterward started being conducted on a quarterly basis. The EPH collects socioeconomic
information on education, employment status, hours and sector of work, tenure at current job, among other information. As it is the case with many national labor surveys, the EPH has a rolling unbalanced panel structure, which allows me to follow workers over a year and construct transition rates across sectors. Appendix C.1 provides further details of the survey; the sample restrictions and the way variables were constructed.

One of the benefits of using these data is that they contain information on whether the worker’s employer makes social security contributions. In the literature that studies informal labor markets, workers are usually classified as formal or informal based on this information (Gasparini and Tornarolli (2009)). In this paper, I assume that all informal workers work in the competitive sector and all formal workers are unionized. The reason for making this assumption is twofold. First, the wages of more than 80% of formal workers are subject to union bargaining in Argentina (Palomino and Trajtemberg (2006)). Second, given the lack of compliance with social security payments, an employer might not have strong incentives to comply with the outcomes of wage negotiations conducted between unions and firms’ representatives.

Aggregate series on investment, government and external debt, tradable and non-tradable output were obtained from Argentinian National Accounts. The stock of aggregate capital was constructed following the perpetual inventory method.\textsuperscript{20} Since there is no information available on national labor shares by sector I follow Uribe (1997) and fix the wage bill shares in the tradable and non-tradable sectors to 0.48 and 0.63, respectively.\textsuperscript{21} Then, the competitive/unionized wage bills are constructed by first inflating the wage bills of the non-tradable sector obtained from the household survey. Then, the wage bills of the unionized and competitive non-tradable sectors obtained from the household survey are used to impute the labor share as a fraction of total non-tradable GDP for each sub-sector.

4.2. Estimation Strategy

The estimation of the model’s steady state is based on the Method of Simulated Moments (MSM) (Gouriéroux and Monfort (1997)) and uses data from the Argentinian Household Survey and National Accounts for the period 1995:Q1 to 1999:Q4. The 2001 recession that occurred in Argentina is relevant for two reasons. First, as shown in Section 2 Argentina is a country with heterogeneous degrees of downward nominal wage rigidities across labor markets. Therefore, this episode is illustrative of the potential distributive effects that exchange rate policy might have had. Second, the recession led to the elimination of the Convertibility Plan implemented in 1991, which pegged the Argentine peso to the U.S. dollar. However, during the same episode the economy was subject to other large economic shocks, as for example

\textsuperscript{20} Unfortunately, there is no information available that would allow me to construct series of sectoral capital.\textsuperscript{21} The magnitudes of these labor shares are consistent with the aggregate labor shares computed for Argentina elsewhere in the literature. See Frankema (2010), Guerriero (2012) and Galiani and Gerchunoff (2003) for estimates of aggregate labor shares.
the sovereign debt default of $100 billion of its external government debt, which represented 7 percent of its 2001 GDP (Arellano (2008)). Since the focus of this paper is on the effects of the nominal devaluation, I abstract from the additional effects that the default might have had and estimate the steady state of the model by targeting moments from the pre-recession period.

Before proceeding with the estimation, I fix some standard parameters from the macroeconomics literature. The periodicity of the model is set to a quarterly basis. The list of fixed parameters and their corresponding values are shown in Table 1. The subjective discount factor is fixed at 0.9909 to calibrate a quarterly real interest rate equal to 1% and the elasticity of inter-temporal substitution is set to a value of 0.5, which are standard values in the quantitative business cycle literature. The probability of death that workers face is set to 0.00625, which matches an average of 40 years of labor market experience from age 25 to 65.

The elasticity of substitution between the tradable and non-tradable final goods was estimated using time series data from Argentina to be 0.44 by Gonzalez-Rozada et al. (2004), a value consistent with estimates from cross-country analysis by Stockman and Tesar (1995). Given the absence of data on output or consumption disaggregated at the formal/informal level, I set the elasticity of substitution between intermediate non-tradable goods to a value of 1.43, which is taken from a paper that studies the formal/informal labor market in Brazil (Ulyssea (2010)). The tax rate that unionized workers must pay is set to 30% (Ferreres (2005)), the depreciation rate of capital is set to 0.025 per quarter (Artuç et al. (2013)), and the bargaining power of the union is set to 0.5 (Gertler and Trigari (2009)), all values commonly used in the business cycle literature. Following Schmitt-Grohé and Uribe (2003) the adjustment costs of bonds that the capitalist faces is set to the minimum value that guarantees convergence back to the steady state value of bond holdings.

A key parameter of the model is $\kappa$, which determines the degree of nominal wage rigidities in the unionized sectors. The value of this parameter is set to 0.99, which implies that nominal wages can decline up to 4% in a year. In Appendix A.1 I show that, once controlling for workers’ observed heterogeneity, the average percent decrease in nominal union wages is 0.9% per quarter (with a median of 1.1% and a maximum of 1.7%).

After fixing a subset of the parameters that parameterize the model, there remain 30 parameters to be estimated which are listed in Table 2. Most of these parameters are estimated using the predictions of the steady state equilibrium of the model. Once these parameters are estimated, the adjustment cost of capital is calibrated to match the change in the investment-output ratio found in the data during the recession period.

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22 Several papers in the sovereign debt literature have provided a quantitative analysis of this episode. For example, see Arellano (2008), Aguiar and Gopinath (2006), Mendoza and Yue (2012) and Perez (2014).
Table 1. Fixed Parameters Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective discount factor $\beta$</td>
<td>0.9909</td>
<td>1% real interest rate</td>
</tr>
<tr>
<td>CRRA $\sigma$</td>
<td>0.5</td>
<td>Standard RBC literature</td>
</tr>
<tr>
<td>Probability of death $\gamma$</td>
<td>0.00625</td>
<td>Avg. life expectancy</td>
</tr>
<tr>
<td>Elast. of subst. final goods $\xi$</td>
<td>0.44</td>
<td>Gonzalez-Rozada et al. (2004)</td>
</tr>
<tr>
<td>Elast. of subst. interm. goods $\nu$</td>
<td>1.43</td>
<td>Ulyssea (2010)</td>
</tr>
<tr>
<td>Tax rate on labor income $\tau$</td>
<td>0.3</td>
<td>Ferreres (2005)</td>
</tr>
<tr>
<td>Depreciation rate of capital $\delta$</td>
<td>0.025</td>
<td>Artuç et al. (2013)</td>
</tr>
<tr>
<td>Union bargaining power $\eta$</td>
<td>0.5</td>
<td>Gertler and Trigari (2009)</td>
</tr>
<tr>
<td>Adjustment cost of assets $g$</td>
<td>0.0025</td>
<td>Schmitt-Grohé and Uribe (2003)</td>
</tr>
<tr>
<td>Adjustment cost of wages $\kappa$</td>
<td>0.99</td>
<td>Schmitt-Grohé and Uribe (forthcoming)</td>
</tr>
</tbody>
</table>

Notes: The table displays the set of parameters that are fixed outside the estimation of the model. The first and second column displays an explanation as well as the notation of each model parameter. The third column displays the value and the last column shows the source or target of each parameter. The time unit is set to one quarter.

The overall estimation procedure is the following. Let $P$ denote the set of parameters to be estimated. The MSM estimator is defined as

$$\hat{P} = \arg \min_P (m^{Data} - m^{Sim}(P))^TW(m^{Data} - m^{Sim}(P))$$

where $W$ is positive definite weighting matrix, $m^{Data}$ is a vector that stacks all the moment conditions from the data and $m^{Sim}(P)$ is a vector of moment conditions computed from the simulated data. With the estimated parameters in hand, the asymptotic standard errors of the estimates follows standard MSM formulas.

The structural estimation of the model requires defining a set of moment conditions informative enough about the statistical relationship found in the data for the parameters to be estimated. The moment weighting matrix $W$ is a diagonal matrix that gives a weight to each moment equal to the inverse of the number of moments in each set of moments. Also, additional weight is given to moments related to sectoral wage differentials, workers’ labor market status and annual transition rates. The numerical minimization is carried out by particle swarm optimization, which is a standard global stochastic numerical optimization routine and similar in spirit to simulated annealing.

The asymptotic covariance matrix of the parameter estimates is computed by assuming independence between aggregate and microeconomic moments. The covariance matrix of moments obtained from the household survey was computed by block bootstrap at the worker level. The covariance matrix of aggregate moments was computed using a stationary bootstrap that allows for arbitrary stationary time series correlations (Politis and Romano (1994)). This matrix imposes a zero variance for the net foreign debt-to-output ratio (there are no series computed at a quarterly frequency) and for the labor share in the tradable sector (the shares in the non-tradable sectors differ across years because of their dependence on microdata from the household survey).
Table 2. Set of Parameters to be Estimated by MSM

<table>
<thead>
<tr>
<th>Description</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agents’ Problem</strong></td>
<td></td>
</tr>
<tr>
<td>Steady state level of Gov. bonds</td>
<td>$\bar{b}_g$</td>
</tr>
<tr>
<td>Steady state level of Cap. bonds</td>
<td>$\bar{b}_k$</td>
</tr>
<tr>
<td>Share of tradable consumption</td>
<td>$\zeta$</td>
</tr>
<tr>
<td>Parameters of AR(1) productivity</td>
<td>$\sigma_z, \rho_z$</td>
</tr>
<tr>
<td>Cost of LM participation</td>
<td>$\iota$</td>
</tr>
<tr>
<td>Exogenous separation rates</td>
<td>$\psi^s$</td>
</tr>
<tr>
<td>Arrival rates of job news</td>
<td>$n^{s,s'}$</td>
</tr>
<tr>
<td>Search flexibility</td>
<td>$\lambda^s$</td>
</tr>
<tr>
<td>St. dev. of preference shocks</td>
<td>$\sigma_\epsilon$</td>
</tr>
<tr>
<td><strong>Firm’s Problem</strong></td>
<td></td>
</tr>
<tr>
<td>Share of unionized goods</td>
<td>$\mu_N$</td>
</tr>
<tr>
<td>Share of labor</td>
<td>$\alpha^s$</td>
</tr>
<tr>
<td>Share of capital</td>
<td>$\theta^s$</td>
</tr>
</tbody>
</table>

identified. The following set of (average) moments were computed from the data and used in the MSM objective function:

- **Household Survey Data**
  - Parameter estimates of wage process (3).\(^{25}\)
  - The mean hourly real wage by sector.\(^{26}\)
  - The fraction of workers that are either non-participating in the labor market, unemployed or employed in each productive sector.
  - One-year ahead transition rates between non-participation, unemployment or employment in each productive sector.
  - Distribution of job tenure (1, 2-4, 5-20, 21+ quarters) by current sector of employment.
  - Distribution of previous sector of employment for currently unemployed workers.
  - Distribution of length of unemployment spell (1, 2, 3-4, 5+ quarters) by previous sector of employment.

- **National Accounts Data**

\(^{25}\) The parameters determining the AR(1) that governs idiosyncratic productivity was estimated applying the methodology presented in Floden and Lindé (2001). Appendix C.1 provides further details.

\(^{26}\) Hourly real wages are standardized by the average hourly real wage paid in the unionized non-tradable sector.
– The share of tradable output.
– The net foreign debt-to-output ratio.
– The public debt-to-output ratio.
– The investment-output ratio.
– The labor share by sector.

The simulated moments are generated for any given set of parameters by computing the steady state of the model and by simulating the behavior of 100,000 workers. Notice that some of the data moments involve the distinction between non-participating and unemployed workers. The model also allows for a simple way to make this distinction. If in period $t - 1$ the worker was not employed, he is classified as unemployed in period $t$ if he decided to participate in the labor market but the search and/or the job rationing friction prevented him from finding a job. Similarly, if the workers were employed in any sector at period $t - 1$, he is classified as unemployed at period $t$ either if he is not separated and does not find a job when choosing to participate in the labor market (due to job rationing frictions), or when he is exogenously separated and he would choose to search for a job in case he wasn’t. This classification is consistent with the notion of unemployment used by the Argentinian statistical agency, which classifies as unemployed any worker who is not currently employed and who has been actively searching for jobs during the week previous to the interview (or has been previously searching but stopped during the previous week due to circumstantial reasons).

The complexity of the model prevents me from obtaining an analytical solution, which makes the provision of a detailed description of the mapping between structural parameters and specific moments infeasible. Furthermore, it is not the case that each parameter is uniquely identified by a specific moment from the data. Nevertheless, I provide a heuristic identification argument based on economic intuition to describe how certain moments should be more informative of specific structural parameters. To provide more formal evidence of this mapping, Appendix C.4 presents the Jacobian matrix of the derivatives of each targeted moment with respect to the vector of parameters (expressed in terms of elasticities).

First, consider the parameters that enter the capitalist’s problem. The parameter $\bar{b}_g$ determines the capitalist’s level of debt in the steady state. The target for setting this parameter is the average foreign debt-to-output ratio during the 1995-1999 period of 23.2% reported by Lane and Milesi-Ferretti (2007). In order to match this target, I aggregate the steady state level of debt of the capitalist with the aggregate level of government debt and aggregate level of assets held by the workers, and express it as a fraction of annual real GDP. The level of government debt in steady state $\bar{b}_g$ is pinned down by the share of total public debt to aggregate annual GDP. The utility weight $\zeta$ in the CES aggregator determines the expenditure share of tradable goods. This parameter is disciplined by the average share of tradable GDP to aggregate GDP.
Next, consider the parameters that affect the decision made by the workers. The labor market decisions of the worker can be separated in two stages. In the first stage, a worker must decide whether to participate in the labor market or not. This decision is affected by three elements: the level of accumulated assets, the level of idiosyncratic productivity and the fixed cost of labor market participation. The first is endogenous and is a function of the labor market histories of each worker and the parameters governing such histories. The remaining two are exogenous. The parameters of the AR(1) idiosyncratic productivity process are disciplined by the parameters of the AR(1) process that I estimate using observed worker-specific real hourly wages and the methodology presented in Floden and Lindé (2001). The Jacobian confirms this relationship, but also shows that the autocorrelation coefficient is positively associated with the share of workers that do not participate in the labor market, negatively with the external debt-to-output ratio (since if affects aggregate assets held by workers) and that it has a large impact on the persistence of choices related to the labor market. On the other hand, the standard deviation is negatively associated with the debt-to-output ratio since a more volatile income process increases the average level of assets held by the workers due to precautionary motives. Since the estimation is based on wages of workers that optimally decided to participate in the labor market, there is a problem of self-selection based on unobservables (Heckman (1979)). However, my estimation method takes self-selection fully into account since the parameters of the AR(1) are embedded in the estimation routine. Holding other parameters constant, the fixed cost of labor market participation \( \iota \) determines the fraction of workers that optimally choose to remain non-employed.

Conditional on the worker deciding to participate in the labor market, he could be employed in any of the sectors or unemployed. The sectoral labor supply choice is affected by sectoral differentials in the wage per unit of efficiency labor, the arrival rates of job news from unemployment and the probabilities that allow the worker to make a job-to-job transition. Similarly, workers might end up unemployed either by choice or due to an exogenous separation shock. For a given differential in sectoral wages, these transitions are governed by the arrival rates of job news \( n^{s,s'} \), the exogenous separation rates \( \psi^s \) and the parameters that affect the flexibility of job search while unemployed \( \lambda^s \). These parameters determine sectoral employment rates, the aggregate unemployment rate and changes in the labor market status of workers. For example, if \( \psi^{s'} = 0 \) and \( n^{0,s'} = 1 \) for all \( s' \in \{ T, NU, NC \} \), then unemployment would be zero. Similarly, if \( n^{s,s'} = 0 \) for some \( s \neq 0 \) and \( s \neq s' \) any transition from one sector to another would require spending a period unemployed. In order to set these parameters, I target the share of workers in each labor market status and one-year ahead transition matrix between all possible labor market states to identify them. I also target the distribution of the previous sector of employment for currently unemployed workers which, combined with the aggregate fraction of workers that are unemployed, defines a sector-specific unemployment.
rate. In order to identify the parameters that determine the flexibility of job search I target the fraction of workers that return to the same sector of previous employment after going through an unemployment spell. Finally, since the search friction and the job rationing friction present in the unionized sectors are not separately identified in the steady state, I choose to target a job rationing probability equal to one. In other words, the estimation imposes that there is no job rationing in steady state.

The fact that the model frequency is quarterly but the transition matrix is computed at an annual frequency is problematic, since workers could be making transitory transitions that are not captured on an annual frequency. For this reason, I complement this set of targeted moments with additional moments that are related to the persistence of the labor market status of each worker. In particular, I include the distribution of job tenure by current sector of employment and the distribution of the length of unemployment spells by previous sector of employment. While the former is informative about short term transitions that involve a spell of employment in any of the sectors, the latter is informative about short term transitions that involve being unemployed for a short period of time.

The Jacobian confirms the fact that the separation rates and the probability of hearing news about a job from unemployment are mostly informed by the transition rates into and out of unemployment, the distribution of the length of unemployment spells and sector-specific unemployment rates. Similarly, the probabilities of making job-to-job transitions are related to the transition rates across sectors over the period of one year. Also, the probability of making job-to-job transitions from the competitive sector to any of the unionized sectors has a large impact on the duration of unemployment spells. The higher this probability is, the higher is the fraction of workers choosing to search for jobs in the competitive sector, which becomes more attractive due to the increased probability of transitioning into a better-paid job.

Labor market choices are subject to iid preference shocks $\epsilon_{it}$ that are distributed according to a type 1 Extreme Value distribution with location parameter $0.5772\sigma_\epsilon$ and scale parameter $\sigma_\epsilon$. The role of these preference shocks is to generate gross flows that are larger than net flows, which is a feature of the data. For example, as $\sigma_\epsilon \to 0$ all groups of workers that prefer a sector over the others choose that sector. On the other hand, as $\sigma_\epsilon \to \infty$ the relative attractiveness of any sector does not play any role in sectoral choices, and workers choose sectors randomly. Therefore, for a given set of parameters that define the relative attractiveness of each labor market status, $\sigma_\epsilon$ is identified by the overall sectoral choices and transition rates. In particular, the Jacobian shows that transitions involving the non-participation state are mostly affected by this parameter.

Finally, there are seven parameters that determine the behavior of the supply side of the economy. The parameter $\mu_N$ affects the expenditure share of the unionized variety in the final
non-tradable good aggregator. A high demand for the unionized variety increases its price, which in turn allows for a higher level of employment and wages in the unionized sector relative to the competitive sector. However, since this parameter has a large impact on relative wages, the Jacobian shows that this parameter has a large impact on almost all moments related to the labor market histories of workers. The vector of parameters $\alpha^s$ and $\theta^s$ determine the labor and capital share in each sector. In the case of the non-tradable sector, since the unionized and competitive non-tradable output is not separately computed in National Accounts, I target the labor shares of each sector as a fraction of total non-tradable output. Furthermore, since there is no available information to compute sectoral capital, I target the average aggregate investment-to-output ratio of 20%.

4.3. Estimation Results

In this section, I present and describe the parameter estimates that were obtained from the MSM estimation procedure. Table 3 shows the estimates of the Cobb-Douglas production function of each sector. In all cases, the production functions exhibit decreasing returns to scale. The estimated labor shares differ in comparison to standard parameter values used in the RBC literature, especially those calibrated with data from developed countries. The main reason for this is that labor shares in developing countries are lower than in developed countries, even after making adjustments for self-employment income and related issues (Gollin (2002)). However, the value of these parameters are similar to those estimated by Artuç et al. (2013) using plant-level panel data from the manufacturing sector in Argentina from 1994 to 2001 and to those estimated by Pavcnik (2002) using data from the Chilean census of manufacturing plants.

<table>
<thead>
<tr>
<th>Table 3. Parameters: Firms’ Problem</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>$\alpha^s$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$\theta^s$</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

Notes: This table shows the parameter estimates of the Cobb-Douglas production function in each sector. These estimates are obtained using data from the Argentinian Household Survey and aggregate data from National Accounts from 1995 to 1999. The estimation procedure is the overidentified MSM. The standard errors (in parenthesis) are computed by assuming independence between micro- and macro-moments in the data, bootstrapping the covariance matrix of aggregate moments allowing for arbitrary stationary time series correlation and block bootstrapping the covariance matrix of micro-moments at the worker-level.
Table 4 presents the estimates of the parameters that affect the rate at which workers lose their jobs, find new jobs and transition across sectors. The separation rates are quite low in all cases, with the separation rates from formal jobs being the lowest. In terms of probabilities of hearing news about a job, it is much harder to find a formal job than an informal job. This means that a higher probability of finding an informal job compensates for the lower wage it offers. The same is true for the probability of finding a tradable unionized job since, as we will see later, it offers a slightly lower wage than the non-tradable unionized sector. Similar differences in the separation and job finding rates have been found in Meghir et al. (2015), which studies the formal and informal labor markets in Brazil.

The probabilities of making job-to-job transitions from the competitive to the unionized sectors are high relative to the probabilities of transitioning to those sectors from unemployment. Thus, the model features career-ladder dynamics, by which unemployed workers first find a competitive job and over time they are able to transition to a better-paid unionized job. This is consistent with the fact that in the data competitive workers tend to be younger and with less experience. The model also assigns a high rate of arrival of a possibility to transition to a competitive job once the worker is employed in an unionized job. Since the wage per efficiency unit is much lower in the competitive sector, the only reason a worker might make this type of transition is due to a large idiosyncratic preference shock in the competitive sector. Given the estimated variance of these shocks, few workers that are given the possibility to make this transition choose to do so. Therefore, the model must assign a high probability in order to generate the observed flows from an unionized to a competitive job (this also explains the large standard errors associated with these parameters).

Table 5 presents the estimates of the remaining parameters. In order to generate the wage gap between the unionized and competitive sector the model assigns a larger demand share to the unionized sector by setting $\mu_N$ to 0.85. Given that in steady state the aggregate amount of assets held by the workers is 10.2, the estimation yields a level of capitalist’s debt $\bar{b}_k$ of 9.38 in order to match a debt-to-output ratio of 23%. In order to match a share of tradable output of 25%, the model requires a share of tradable consumption $\zeta$ of 0.087. The estimated variance of the preference shocks is 0.115. The estimated AR(1) process governing the worker’s idiosyncratic has an autocovariance of 0.98 and a standard deviation of 0.07. Once annualized, the process exhibits an autocovariance of 0.936 and a standard deviation of 0.15, which are closed to the estimated values of 0.92 and 0.21 by Floden and Lindé (2001). Finally, the parameter that was not part of the estimation, the adjustment cost of capital $\Phi$, is set to 1.5. This value was set to target in the counterfactual scenario with a fixed exchange rate the observed drop in the investment-to-output ratio from 20% to 14% during the Argentinian recession.
**Table 4. Parameters: Transition Rates**

<table>
<thead>
<tr>
<th></th>
<th>Tradable</th>
<th>Non-Tradable</th>
<th>Non-Tradable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unionized</td>
<td>Competitive</td>
</tr>
<tr>
<td>Panel A: Separation Rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\psi_s^*$</td>
<td>0.025</td>
<td>0.023</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.001)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Panel B: Search flexibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_s$</td>
<td>0.564</td>
<td>0.232</td>
<td>0.851</td>
</tr>
<tr>
<td></td>
<td>(0.218)</td>
<td>(0.042)</td>
<td>(0.119)</td>
</tr>
<tr>
<td>Panel C: Arrival Rates of Job News</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Employment</td>
<td>0.078</td>
<td>0.056</td>
<td>0.567</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.005)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>Tradable</td>
<td>-</td>
<td>0.027</td>
<td>0.852</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>(0.007)</td>
<td>(4.495)</td>
</tr>
<tr>
<td>Non-Tradable Unionized</td>
<td>0.034</td>
<td>-</td>
<td>0.872</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>-</td>
<td>(2.187)</td>
</tr>
<tr>
<td>Non-Tradable Competitive</td>
<td>0.011</td>
<td>0.053</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>-</td>
</tr>
</tbody>
</table>

**Notes:** This table shows the parameter estimates that affect workers’ transition across labor market states. These estimates are obtained using data from the Argentinian Household Survey and aggregate data from National Accounts from 1995 to 1999. The estimation procedure is the overidentified MSM. The standard errors (in parenthesis) are computed by assuming independence between micro- and macro-moments in the data, bootstrapping the covariance matrix of aggregate moments allowing for arbitrary stationary time series correlation and block bootstrapping the covariance matrix of micro-moments at the worker-level.

**Table 5. Remaining Parameters**

<table>
<thead>
<tr>
<th>$\mu_N$</th>
<th>$\hat{b}_k$</th>
<th>$\hat{b}_g$</th>
<th>$\zeta$</th>
<th>$\sigma_\epsilon$</th>
<th>$\rho_z$</th>
<th>$\sigma_z$</th>
<th>$\nu$</th>
<th>$\Phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.85</td>
<td>-9.38</td>
<td>-2.40</td>
<td>0.07</td>
<td>0.11</td>
<td>0.98</td>
<td>0.07</td>
<td>0.76</td>
<td>1.50</td>
</tr>
<tr>
<td>(0.03)</td>
<td>(1.25)</td>
<td>(0.32)</td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.00)</td>
<td>(0.01)</td>
<td>(0.14)</td>
<td>-</td>
</tr>
</tbody>
</table>

**Notes:** This table shows the parameter estimates of the remaining set of parameters. These estimates are obtained using data from the Argentinian Household Survey and aggregate data from National Accounts from 1995 to 1999. The estimation procedure is the overidentified MSM. The standard errors (in parenthesis) are computed by assuming independence between micro- and macro-moments in the data, bootstrapping the covariance matrix of aggregate moments allowing for arbitrary stationary time series correlation and block bootstrapping the covariance matrix of micro-moments at the worker-level.
4.4. *Goodness of Fit*

The MSM procedure made use of 71 moments to estimate 29 parameters, which means that the model is over-identified. I now present the goodness of fit of the model relative to the data. Table 6 presents the average nominal wage across workers employed in each sector. These averages were standardized by the average wage paid in the non-tradable unionized sector. The model is able to reproduce the wage gap observed in the data quite closely. As it was previously mentioned, these wage differentials are compensated with differentials in the probabilities of hearing news about a job in each sector. Thus, the lower is the average wage in a sector relative to the wage paid in the non-tradable unionized sector, the higher is the probability of finding a job in that sector relative to the probability of finding a job in the non-tradable unionized sector. The bottom part of Table 6 presents the goodness of fit of the parameters of the AR(1) process that governs idiosyncratic productivity and shows that the model is able to replicate the process observed in the data.

One moment that was not targeted in the estimation process is the Gini coefficient of labor income. In the micro-data the average Gini coefficient of hourly wages in the pre-crisis period is 0.41. The Gini coefficient computed from the simulated data in the model is 0.22 (and increases to 0.27 when including non-labor income in the calculation). Therefore, the model is able to generate around 50% of the observed wage inequality in the data. This level of earnings inequality translates into substantial wealth inequality. The implied Gini coefficient for workers’ asset holdings is 0.64. Although there is no data in Argentina that would allow me to compute an equivalent statistic, data from other countries show that such level of wealth inequality is plausible. For example, using data from the Survey of Consumer Finances in the US, Castañeda et al. (2003) report a Gini coefficient of wealth of 0.78.\(^\text{27}\)

Table 7 shows the composition of the labor force in terms of labor market status. Although the model over-predicts the share of workers employed in the tradable unionized sector, the overall distribution of workers is well replicated.

Table 8 presents the one-year ahead transition rates between non-participation, unemployment or employment in each productive sector. Panel A presents the computed statistics from the data and Panel B presents the simulated statistics from the model. Non-participation and employment in the unionized sectors are persistent states in the data. On the contrary, the transition out of the competitive sector is much higher and the unemployment state is even more short-lived. The model can replicate all of these facts.

The data also shows that transitions into non-participation are more frequent from workers employed in the competitive sectors than those employed in the unionized sector. Although

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\(^{27}\) The model also generates reasonable values for some points of the Lorenz curve of workers’ wealth. For example, in the model the shares of total assets held by each quintile are: 0.6%, 2.7%, 8.9%, 22.4% and 65.4%. The equivalent numbers for the US are: -0.4%, 1.7%, 5.7%, 13.4% and 79.5% (Castañeda et al. (2003)).
Table 6. Real Hourly Wage and Idiosyncratic Productivity: Pre-Crisis Period

<table>
<thead>
<tr>
<th>Sector</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tradable Unionized</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>Non-Tradable Unionized</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Non-Tradable Competitive</td>
<td>0.62</td>
<td>0.61</td>
</tr>
<tr>
<td>Autocorr. AR(1) $\rho_z$</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>St. Dev. AR(1) $\sigma_z$</td>
<td>0.09</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Notes: The top panel shows the average wage earned by workers in each sector. Real hourly wages are standardized by the data average real hourly wage and the model average real wage paid in the Non-Tradable Unionized sector, respectively. The bottom panel presents the parameters of the AR(1) process that governs workers’ idiosyncratic productivity. The first column refers to moments computed using micro data from Argentinian household survey between 1995 and 1999. The second column refers to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.

Table 7. Labor Market Status (%): Pre-Crisis Period

<table>
<thead>
<tr>
<th>Sector</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Participation</td>
<td>33.5</td>
<td>33.6</td>
</tr>
<tr>
<td>Unemployment</td>
<td>7.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Tradable Unionized</td>
<td>7.8</td>
<td>10.7</td>
</tr>
<tr>
<td>Non-Tradable Unionized</td>
<td>33.0</td>
<td>29.4</td>
</tr>
<tr>
<td>Non-Tradable Competitive</td>
<td>17.9</td>
<td>17.4</td>
</tr>
</tbody>
</table>

Notes: The table shows the fraction of workers that are in each labor market status. The first column refers to moments computed using micro data from Argentinian household survey between 1995 and 1999. The second column refers to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.

The transitions rates from the unionized sectors to non-participation generated by the model are a bit higher, the general pattern holds. Since the estimated wage per unit of efficiency labor is lower in the competitive sectors, workers employed there are more likely to decide not to participate in the labor market when the idiosyncratic productivity falls below a certain threshold. For the same drop in idiosyncratic productivity and holding the worker’s level of assets constant, a worker employed in the unionized sector might decide to keep working since the higher wage per efficiency unit of labor offered in the unionized sector compensates the drop in productivity.

The data shows that workers on average exit unemployment by finding a job in the competitive sector. Also, once employed in the competitive sector there is a 20% probability of transitioning into the unionized sector, which is also predicted by the model. However, the
Table 8. Annual Transition Rates (%): Pre-Crisis Period

Panel A: Data

<table>
<thead>
<tr>
<th></th>
<th>Non-Participation</th>
<th>Unemployment</th>
<th>Tradable</th>
<th>Non-Tradable</th>
<th>Non-Tradable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Participation</td>
<td>86.1</td>
<td>5.8</td>
<td>0.2</td>
<td>1.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Unemployment</td>
<td>31.7</td>
<td>28.9</td>
<td>2.5</td>
<td>11.6</td>
<td>25.3</td>
</tr>
<tr>
<td>Tradable Union.</td>
<td>1.6</td>
<td>4.6</td>
<td>77.4</td>
<td>9.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Non-Tradable Union.</td>
<td>2.5</td>
<td>3.3</td>
<td>2.2</td>
<td>85.3</td>
<td>6.7</td>
</tr>
<tr>
<td>Non-Tradable Comp.</td>
<td>12.3</td>
<td>9.7</td>
<td>3.7</td>
<td>16.4</td>
<td>57.9</td>
</tr>
</tbody>
</table>

Panel B: Model

<table>
<thead>
<tr>
<th></th>
<th>Non-Participation</th>
<th>Unemployment</th>
<th>Tradable</th>
<th>Non-Tradable</th>
<th>Non-Tradable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Participation</td>
<td>79.3</td>
<td>9.6</td>
<td>1.6</td>
<td>1.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Unemployment</td>
<td>31.0</td>
<td>24.2</td>
<td>4.3</td>
<td>6.3</td>
<td>34.2</td>
</tr>
<tr>
<td>Tradable Union.</td>
<td>7.3</td>
<td>3.9</td>
<td>80.3</td>
<td>7.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Non-Tradable Union.</td>
<td>6.7</td>
<td>3.2</td>
<td>2.6</td>
<td>86.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Non-Tradable Comp.</td>
<td>8.5</td>
<td>8.7</td>
<td>3.8</td>
<td>16.2</td>
<td>62.9</td>
</tr>
</tbody>
</table>

Notes: The table shows one-period ahead transition rates across all possible labor market statuses. Rows correspond to status of origin and columns refer to status of destination. The top panel corresponds to moments computed using micro data from Argentinian household survey between 1995 and 1999. The bottom panel refers to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.

The model is not able to generate enough transitions from the unionized sectors into the competitive one. The reason is that the gap in the wage per unit of efficiency labor is so large that few workers decide to switch based on iid preference shocks. It is possible that the introduction of worker-specific permanent characteristics that affect the sector-specific return to labor market participation (such as education) generates a better fit of the data. Such permanent differences would allow the model to reproduce observed wage differentials across sectors without relying so much on differences in the wage per unit of efficiency labor. In that case, workers would be more responsive to transitory preference shocks and more willing to transition into lower-paying jobs.

I now investigate whether the data are consistent with the sector-specific distributions of tenure predicted by the model. In Figure 4 the data shows that the distribution of job tenure in the unionized sectors exhibits a small fraction of workers with 1 quarter of tenure and a large fraction of workers with more than 5 years of tenure. In comparison to these distributions, the distribution of tenure of workers employed in the competitive sector has a larger fraction of
workers with just a quarter of tenure and much smaller fraction of workers with tenure above 5 years. The model also predicts the overall pattern found in the data. However, the model is unable to generate enough persistence, so that the fraction of workers with more than 5 years of tenure falls short in all sectors relative to the data. However, it is still remarkable that the model generates such long persistence in labor market status, without additional features that increase the labor market return while employed (in particular, the model does not include any life-cycle component nor returns to tenure). This degree of persistence is achieved by the high persistence of the AR(1) process that governs idiosyncratic productivity and due to the low probabilities of finding an unionized job when unemployed, which makes the worker want to remain employed once a job is found.

Although the transition rates that are being targeted are computed at an annual frequency, the model is able to generate higher frequency movements. One example of this is the match of the low fraction of workers in the unionized sectors with just one quarter of tenure and the larger fraction of workers employed in the competitive sector that just entered the sector.

**Figure 4. Distribution of Tenure by Sector of Employment**

<table>
<thead>
<tr>
<th>Tradable Unionized</th>
<th>Non-Tradable Unionized</th>
<th>Non-Tradable Competitive</th>
</tr>
</thead>
</table>

**Notes:** The figure shows the distribution of tenure by current sector of employment. Bins are expressed in quarters. Bars in blue correspond to moments computed using micro data from Argentinian household survey between 1995 and 1999. Bars in red refer to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.

The last set of aggregate targeted moments and the predictions generated by the model are presented in Table 9. Overall, the model can generate many key patterns observed in the data with relatively few parameters. The fit of the model to the remaining set of moments computed from the data is presented in Appendix C.3.
Table 9. Aggregates Moments: Pre-Crisis Period

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment-Output Ratio</td>
<td>0.20</td>
<td>0.19</td>
</tr>
<tr>
<td>External Debt-Output Ratio</td>
<td>-0.23</td>
<td>-0.24</td>
</tr>
<tr>
<td>Govt. Debt-Output Ratio</td>
<td>-0.36</td>
<td>-0.36</td>
</tr>
<tr>
<td>Share of Tradable Output</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Labor Share Tradable Unionized</td>
<td>0.48</td>
<td>0.46</td>
</tr>
<tr>
<td>Labor Share Non-Tradable Unionized</td>
<td>0.46</td>
<td>0.48</td>
</tr>
<tr>
<td>Labor Share Non-Tradable Competitive</td>
<td>0.17</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Notes: The table shows aggregate moments targeted during the estimation procedure. The first column refers to moments computed using aggregate data from Argentinian national accounts and aggregate balance sheets of the banking sector between 1995 and 1999. The second column refers to equivalent moments computed using the model predictions in the steady state equilibrium.

5. Findings from the Model

In this section, I use the estimated model to assess the economic effects that nominal wage rigidities might have on an economy that undergoes through a recession and the potential effects a nominal exchange devaluation might have. In the main exercises, this recession is generated by a drop in TFP in the tradable sector, which can also be interpreted as a shock to the terms of trade. In the first place, I study the effects of heterogeneous nominal wage rigidities by analyzing the transition dynamics of an economy that goes through a recession episode while keeping the exchange rate fixed. Next I analyze the effects of a nominal devaluation by comparing these transition dynamics with those of an economy that implements a simultaneous devaluation when the TFP shock arrives. Here, I consider two scenarios. In the first scenario, all assets are denominated in foreign currency and the devaluation has real effects by overcoming the nominal rigidities only. In the second, I take into account the revaluation of nominal positions of all agents in the economy generated by the devaluation. Finally, I study the aggregate and distributive welfare effects under each scenario.

5.1. Effects of Nominal Rigidities during a Recession

I begin describing the impact nominal wage rigidities have during a recession period. The baseline results correspond to a TFP shock in the tradable sector only. The magnitude of the shock and its persistence are chosen taking into account the evolution of the terms of trade in Argentina in the years previous to the recession. I choose a drop in tradable TFP of 20% relative to the steady state, which corresponds to the observed change in the terms of trade in Argentina between the peak in 1996 and the trough in 1999. The persistence of the shock is set to 0.8, which is the quarterly equivalent of the persistence estimated by Schmitt-Grohé.
and Uribe (2015) for the process of the terms of trade in Argentina. Although the magnitude of the shock is large enough to overstate the impact on tradable output, the model with fixed exchange rates generates the drop in non-tradable output and the increase in the fraction of unemployed workers observed in the quarter in which the devaluation took place.

Figure 5 shows the impact of the recession on aggregate variables. The figure presents each variable as a percentage deviation from the steady state or, in the case of the labor variables, as the difference in terms of the fraction of the total population with respect to the steady state. Period 1 refers to the impact period, and the effects are shown for the first 40 quarters after the shock. Similarly, Figure 6 shows the labor market dynamics in terms of employment and real wages in the unionized and competitive sectors, separately.

When unionized nominal wages are downwardly rigid, the magnitude of the shock on tradable output is amplified by a reduction of tradable employment and the overall fall in tradable output is 33 percent on impact. Furthermore, the contraction of tradable output spills over to the non-tradable sector, and aggregate output falls by 12.6 percent relative to the steady state. The response of the workers and the capitalist is to decrease consumption by 2.7 percent and to increase the level of aggregate debt by 49 percent.

The reason the shock has a large effect on output is that nominal unionized wages do not decrease, which means that real unionized labor costs are too high and unionized employment must decrease. The impact of nominal rigidities is strong enough to increase the unemployment rate by 8.4 percentage points. In the model, unemployment increases because of two reasons. Since employment is demand-determined in unionized sectors, an increase in the job rationing friction endogenously increases the separation rate of workers. Second, the transition from unionized employment into unemployment decreases the per capita level of real transfers by more than 30 percent. Therefore, a fraction of workers that previously were non-employed decide to start searching for jobs (around 2.5 percent of total population), pushing the unemployment even further.28

However, part of the negative effect of the shock on the unemployment rate is mitigated by an increase in competitive employment. Since the nominal wage paid in the competitive sector is not downwardly rigid, some workers are willing to find employment in this sector at a lower wage. As shown in Figure 6, the influx of workers that were laid-off from the unionized sectors pushes the real competitive wage down by 17 percent, which allows for an increase in competitive employment of 3 percent of the population. Given the differences in demand for the non-tradable unionized and competitive varieties, the compositional change in the non-tradable labor market generates a misallocation of labor resources. Using data from Argentine

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28 This effect is consistent with the results found in Martinoty (2015). Analyzing the same recession with similar data, the author estimates that spouses were 43 percentage points more likely to enter the labor market when their household heads experienced an unexpected displacement.
manufacturing establishments from the annual industrial survey, Sandleris and Wright (2014) find that the productivity of the Argentine economy fell by 11.5 percent between 1997 and 2001 and that the largest contributions to changes in efficiency come from deteriorations in the allocation of labor resources within industries. In this model, such misallocation is the result of heterogeneous degrees of nominal rigidities across sectors. This heterogeneity results in a drop in employment in the non-tradable unionized sector where average labor productivity is 3.2 percent higher on average during the first two years (relative to steady state) and an increase in non-tradable competitive employment where average labor productivity is 4.8 percent lower on average during the first two years.29

Part of the negative effect of the TFP shock is mitigated by changes in the absolute price of the final non-tradable good, which decreases relative to the price of the tradable good. This decline results from the wealth effects of the TFP shock, which induces a reduction in the demand of non-tradable goods. Therefore, the economy experiences a deflation at the onset of the recession of a magnitude of 9 percent. However, the decline in the price of the non-tradable good is not enough to induce the necessary shift in consumption towards the non-tradable good and to avoid the impact on aggregate employment. More importantly, the deflation aggravates the effect of nominal rigidities since unionized real wages end up increasing by 6.7 percent on impact.

Given the negative impact nominal rigidities have when the economy is hit by a shock in the tradable sector, it is interesting to consider whether reducing wages in real terms via a devaluation of the nominal exchange rate could avoid the negative effects on the labor market. In order to isolate the effect of the devaluation on the labor market I momentarily make the assumption that all assets and liabilities are denominated in foreign currency. Therefore, the only effect of the devaluation is to increase the aggregate price level and help the economy overcome the nominal rigidities. In the following analysis, I set the rate of devaluation implemented by the government to 200 percent, which is similar to the devaluation rate experienced during the Argentinian episode in 2001. The results are presented in Figures 5 and 6 with a dashed line.

The nominal devaluation has two effects. First, it allows union wages to decrease in real terms and prevents firms from having to lay off workers. Second, it decreases the relative price of non-tradable goods. This decrease in relative prices induces a larger switch of consumption towards the final non-tradable good, and aggregate consumption increases by 2.0 percent on impact.

29 The economy with fixed exchange rate exhibits an additional source of inefficiency. The increase in the participation rate of workers means that the average idiosyncratic productivity of employed workers is 0.6 percent lower on average during the first two years relative to the steady state. This happens because one of the reasons why workers decide not to participate in the labor market is a low level of idiosyncratic productivity. Given the fixed cost of labor market participation and the fact that transfers are made on a per capita basis, there is room for a transfer scheme between low productivity employed workers and high productivity unemployed workers that would make both better off.
impact. This increase in consumption corresponds to consumption in the non-tradable good, which occurs because firms decide to decrease the level of capital during the period with low productivity and low demand. The shock does not end up having a large impact on consumption since agents increase the net external debt by 29 percent. Both effects prevent the TFP shock from spilling over to the rest of the economy and having an impact on unemployment.

The results also show that the drop in aggregate real wages is indeed lower when the devaluation is implemented than when the exchange rate is maintained fixed. The reason for this difference is the way sectoral variables respond to the shock. The decrease in union real wages does not only benefit workers that would have otherwise lost their job. Since unionized jobs do not become rationed, competitive employment does not increase either by laid off workers that search for jobs there or by workers that would have otherwise made a job-to-job transition to the unionized sector and couldn’t. Therefore, real competitive wages do not need to adjust in order to absorb this inflow of workers. Thus, instead of real union wages increasing by 6.7 percent and competitive wages having to decrease by almost 17 percent when the exchange rate is fixed, the devaluation induces a more symmetric decrease in real wage across sectors. In summary, the devaluation allows the economy to respond to the shock in the same way an economy without nominal rigidities ($\kappa = 0$) would respond to the same shock (results not reported here).

5.2. Revaluation Effects of Nominal Devaluations

Episodes of unanticipated inflation, generated either by a devaluation of the nominal exchange rate or other monetary policies, affect the real value of assets and liabilities held by agents of the economy. In the previous analysis I abstracted from revaluation effects in order to focus on the labor market effects of a nominal devaluation. In this subsection, I study the impact of a nominal devaluation in a similar economy taking into account the effect of the devaluation on the real value of nominal positions, a scenario labeled as “currency mismatch”.\footnote{The previous literature has studied alternative balance sheet effects. See Cook (2004) for a theoretical and Aguiar (2005) for an empirical analysis of the effects of exchange rate devaluations on firms’ balance sheets and its implications for capital investment.}

During such episodes, governments’ fiscal position could deteriorate if tax revenues are mostly denominated in local currency and a fraction of expenditures are denominated in foreign currency (for example public debt of governments from emerging countries, which is typically denominated in foreign currencies). Additionally, governments can affect the extent and distribution of wealth across groups of the population by implementing a scheme of targeted transfers. Therefore, the extent of revaluation effects depend on the specific policies implemented by the government and, in principle, there are many alternatives available.
**Figure 5. Aggregate Effects of Nominal Rigidities**

![Graphs showing various economic indicators over time](image)

**Notes:** Response of output, real wage, real exchange rate, consumption, net external debt and (un-) employment to a 20% shock to TFP in tradable sector with quarterly persistence of 0.8. Label “Fixed Exchange Rate” and “Devaluation - Baseline” refer, respectively, to the model responses with the nominal exchange rate held fixed and with a 200% devaluation of the nominal exchange rate implemented at the onset of the recession (period 1). Impulse responses expressed in percent deviations from steady state, except for employment and unemployment which are expressed as a fraction of total population and as a fraction of the economically active population, respectively.
**Figure 6. Sectoral Effects of Nominal Rigidities**

Notes: Response of sectoral employment and real wages to a 20% shock to TFP in tradable sector with quarterly persistence of 0.8. Label “Fixed Exchange Rate” and “Devaluation - Baseline” refer, respectively, to the model responses with the nominal exchange rate held fixed and with a 200% devaluation of the nominal exchange rate implemented at the onset of the recession (period 1). Impulse responses expressed in percent deviations from steady state for wages and as a fraction of total population for employment.

In this paper I consider policies that are a similar to the ones implemented by the Argentinian government during the episode of analysis. These are the sovereign default and the conversion of dollar-denominated assets/liabilities into peso-denominated assets/liabilities. Days before the devaluation the government decided to declare the intention to default on government debt. It would be hard to imagine these two episodes to be isolated. Had the government not defaulted, the devaluation would have forced the government to implement a larger fiscal reform in order to obtain resources to pay interest on dollar-denominated debt. The second policy is related to the fact that during the years previous to the devaluation the fraction of deposits from and credit to the private sector denominated in US$ increased to up 70% of total deposits and credits. Thus, a nominal devaluation would have had a minor effect on lenders but would severely affect the solvency of borrowers, especially of those with
earnings from the non-tradable sector. In order to avoid these negative effects on borrowers, the government decided to convert all dollar-denominated loans at the rate of US$1=AR$1 and all dollar-denominated deposits at the rate of US$1=AR$1.4. In the following exercises, both effects are taken into account by assuming that a given fraction of assets and all of government’s debt are denominated in nominal terms.\textsuperscript{31} The goal of considering the default episode is not to model the consequences of a sovereign default, but rather to take into account the fact that one potential winner of a nominal devaluation is the government.

Given the lack of detailed information on Argentinian nominal positions at the household level I compute nominal positions as a percentage of GDP for broad groups of agents. In particular, I specify the amount of nominal positions held by the workers, the capitalist and the government. To determine nominal positions I consider the monetary base, loans to and deposits by the private and public sector, and government debt. The necessary information comes from the aggregate balance sheet of the financial sector reported by the Argentinian Central Bank (BCRA) for the 1995-1999 period.

To determine the nominal position of workers as a fraction of GDP I assume that workers hold the entire monetary base, all deposits, a fraction of all the loans made to the private sector\textsuperscript{32} and all domestic public debt. The amount of nominal positions held by the capitalist is computed as the fraction of loans for production purposes. Finally, nominal positions of the government were computed as the sum of total government debt and deposits made by the public sector. While in the data a fraction of these assets and liabilities are denominated in foreign currency, the counterfactual exercises considered here assume that they are all denominated in local currency. The idea is to make the revaluation effect stronger in order to provide an upper bound of the potential effects of the devaluation. Table 10 summarizes the amount of nominal positions of all agents as a fraction of GDP in Argentina:

\begin{table}[h]
\centering
\begin{tabular}{ccc}
Government & Workers & Capitalist \\
\hline
-34.4\% & +29.4\% & -15.7\%
\end{tabular}
\caption{Nominal Positions as a Fraction of GDP}
\end{table}

Notes: Nominal asset positions as a fraction of Argentinian GDP.

\textsuperscript{31} An alternative would be to treat the default as such and compute the actual windfall gain received by the government. Taking into account the restructuring of defaulted Argentinian bonds in 2005, Cruces and Trebesch (2013) estimate a haircut on debt obligations of 76%. With a devaluation rate of 200%, the quantitative implications of interpreting the default episode as a revaluation of peso-denominated debt is close to the observed haircut.

\textsuperscript{32} Data on loans made by the financial sector allows for a decomposition of loans by economic sector of activity of the recipient of the loan. The fraction of loans assigned to workers is the fraction of loans requested by “individuals that work as employees”, which represents 23% of total loans made by the financial sector.
In order to map these magnitudes in the model, I compute the level of assets/liabilities they represent as a fraction of model annual GDP and then express that amount as a fraction of assets/liabilities held by each agent. The resulting fraction is assumed to be denominated in local currency, while the remaining fraction is denominated in foreign currency and therefore not affected by the devaluation.

As can be seen in Table 10, the capitalist and the government benefit from the revaluation of nominal debt. In both cases, the level of debt in steady state is given by a calibrated parameter, so a decision needs to be made regarding the dynamics of both levels of debt during the transition. In order not to induce permanent differences and to make the effects comparable across scenarios, the real value of government’s and capitalist’s debt return to the same value set in the original steady state. Therefore, the original and new steady states are equal in terms of real variables and only differ in nominal terms. In the case of government debt, the path of debt is determined by

$$b_{gt+1} = \rho^t g \hat{b}_g + (1 - \rho^t) \hat{\hat{b}}_g$$

where $\hat{b}_g$ and $\hat{\hat{b}}_g$ denote the starting and the end values of government debt expressed in local currency, and $\rho^t_g = 0.975$. The slow recovery of government debt is motivated by the evolution of government spending in the Argentinian episode, which went from 35% of GDP in the year previous to the devaluation to an average of 30% of GDP during the following 5 years. By following this borrowing pattern, the government runs a temporary fiscal surplus, which can be spent via alternative fiscal policies. Here I consider two different ways of spending the windfall gain. In the first case, the government uses the additional revenue to make government purchases of non-tradable goods (which do not enter in the utility function of any of the other agents). In the second case, the revenue is used to finance a temporary increase in the lump-sum transfer to non-employed workers.

Figure 7 and 8 show the results for aggregate and sectoral variables. I keep the results found in the scenario with the baseline devaluation for comparison purposes. The main benefit in all three scenarios of a devaluation is that it prevents the external shock from propagating to the non-tradable sector and affecting aggregate employment. The difference lays on the cost incurred to attain such a benefit. In the baseline scenario, there is no cost in the devaluation episode since assets are all denominated in foreign currency. In the more realistic scenario in which a devaluation affects the real value of nominal positions, the model dynamics after a shock are determined by what the government does with the windfall gain.

If the government spends the additional resources by increasing government expenditure of non-tradable goods, the economy experiences a temporary increase in non-tradable output of up to 2.9 percent. However, it would be misleading to conclude from this observation that workers are better off. Since a substantial fraction of workers’ assets decline in real value,
workers reduce their consumption by 4.2 percent on impact due to wealth effects and keep their aggregate level of consumption low for a long period of time (Figure 9). The difference is then compensated by an increase in government spending and capitalist’s consumption, who can increase his spending due to the loss of the real value of his nominal obligations. In terms of sectoral variables, unionized employment is relatively stable. The higher demand of non-tradable goods increases wages in that sector, which induces a reduction of tradable employment and an increase in non-tradable employment (the increase in competitive employment is faster due to lower search frictions).

On the other hand, when the government rebates the additional revenues back non-employed workers the dynamics of the economy change substantially. First, the non-tradable output experiences a small but persistent decline. Aggregate employment declines by up to 3.5 percent in the first quarters, the unemployment rate declines by 3.5 percent on impact and the aggregate real wages increases by up to 3.4 percent. The intuition for this is straightforward. The increase in government transfers subsidizes leisure, which induces a fraction of the population to stop working. The sectoral analysis shows that this effect is stronger for workers employed in the competitive sector. Since the wage per efficiency labor is lower in those sectors, competitive workers are the least attached to the labor market and have a higher elasticity of labor supply with respect to government transfers. Unionized employment decreases at a much lower rate. For a given decrease in idiosyncratic productivity, a unionized worker is more likely to keep working given the higher wage per efficiency unit of labor paid in that sector. As time goes by, more and more workers experience large drops in idiosyncratic productivity that make them decide to stop working. The same intuition explains the recovery phase of employment in both sectors.

What is interesting from this last scenario is the evolution of aggregate workers’ consumption, which increases in the first quarters and then remains below the steady state level for a long time. The temporary increase is due to the additional transfers received by the workers and the decrease in the relative price of non-tradable goods. As these benefits fade out, the persistent drop in consumption that results from the decrease in the real value of assets and precautionary motives emerges again. So an increase in government transfers can generate only a transitory relief to the cost generated by revaluation effects. The difference between consumption of the final non-tradable good and output is given by the decrease in capital investment, which decreases in par with the decrease in labor supply.

The observed degrees of persistence are not unusual in this type of models (for example, see Doepke and Schneider (2006)).
**Figure 7. Aggregate Effects of Exchange Rate Policy**

**Notes:** Response of output, real wage, real exchange rate, consumption, net external debt and (un-) employment to a 20% shock to TFP in tradable sector with quarterly persistence of 0.8 and a 200% devaluation of the nominal exchange rate implemented at the onset of the recession (period 1). Labels “Currency Mismatch - Higher Gov. Spending” and “Currency Mismatch - Higher Transfers” refer to the model responses when there is revaluation of nominal positions and the government uses the additional resources to increase consumption of non-tradable goods and the transfers to non-employed workers, respectively. Impulse responses expressed in percent deviations from steady state, except for employment and unemployment which are expressed as a fraction of total population and as a fraction of the economically active population, respectively.
Figure 8. Sectoral Effects of Exchange Rate Policy

Notes: Response of sectoral employment and real wages to a 20% shock to TFP in tradable sector with quarterly persistence of 0.8 and a 200% devaluation of the nominal exchange rate implemented at the onset of the recession (period 1). Labels “Currency Mismatch - Higher Gov. Spending” and “Currency Mismatch - Higher Transfers” refer to the model responses when there is revaluation of nominal positions and the government uses the additional resources to increase consumption of non-tradable goods and the transfers to non-employed workers, respectively. Impulse responses expressed in percent deviations from steady state for wages and as a fraction of total population for employment.

5.3. Welfare Effects of Nominal Devaluations

The previous analysis showed that nominal devaluations have heterogeneous effects across labor markets due to nominal rigidities in unionized sectors. Similarly, the impact of exchange rate policy in the economy is affected by the degree of revaluation of nominal positions held by the agents. In this section, I quantify the welfare effects of exchange rate policy under each of the scenarios previously analyzed. More specifically, I quantify the welfare benefit (cost) of exchange rate policy for each agent in the economy, by computing the percent increase in lifetime consumption stream required by each agent living in the economy under each analyzed scenario to be as well off as an agent living in an economy that remains in steady state. In
Figure 9. Impact on Aggregate Workers’ Assets and Consumption

![Graph showing impact on assets and consumption](image)

**Notes:** Response of aggregate workers’ assets and consumption to a 20% shock to TFP in tradable sector with quarterly persistence of 0.8 and a 200% devaluation of the nominal exchange rate implemented at the onset of the recession (period 1). Labels “Currency Mismatch - Higher Gov. Spending” and “Currency Mismatch - Higher Transfers” refer to the model responses when there is revaluation of nominal positions and the government uses the additional resources to increase consumption of non-tradable goods and the transfers to non-employed workers, respectively. Impulse responses expressed in percent deviations from steady state.

Appendix D I trace the welfare effects of a devaluations on different groups of workers as a function of the devaluation rate.

Figure 10 presents the distribution of workers’ welfare effects expressed in equivalent percentage changes in permanent consumption. A positive (negative) number would indicate that a given worker would require a certain permanent increase (decrease) in steady state consumption in order to be indifferent between remaining in steady state and experience the transition dynamics of a given scenario. The first result that this figure suggests is that exchange rate policy has highly heterogeneous effects on different groups of workers, with a fraction of workers becoming better off and another fraction becoming worse off in each scenario considered. Relative to the scenario in which the exchange rate remains fixed, a nominal devaluation that does not affect the real value of assets and liabilities improves the welfare for a large fraction of workers that would otherwise experience a loss during the currency peg. However, the devaluation also makes a fraction of workers worse off.

When revaluation effects are taken into account Figure 10 shows that the distribution of welfare effects have larger tails. This means that relative to the first two scenarios, there is a larger fraction of workers that become worse off with the devaluation when it affects the real value of nominal positions. Also, the shape of these distributions is affected by what the government does with the windfall gain generated by the reduction in the real value of government debt. When the government uses the additional resources to increase government spending on non-tradable goods the distribution of welfare effects is more skewed to the left.
than when the government redistributes the gain back to non-employed workers. The main reason for this difference is that government spending does not enter into the workers’ utility, so in the first scenario workers are not compensated in any direct way.

**Figure 10. Distribution of Welfare Effects of Exchange Rate Policy**

Notes: Distribution of workers’ welfare effects in each scenario expressed in equivalent change in permanent consumption that would make the worker indifferent between living throughout each scenario and living in an economy that remains in steady state. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario.

The presence of a fraction of workers that become better and worse off in each scenario relative to the steady state suggests the possibility that there are certain workers’ characteristics that determines the welfare effect of a nominal devaluation. The following tables shed light on this issue. Table 11 shows the mean and median welfare effects of exchange rate policy for specific groups of agents. These groups are defined by workers’ characteristics at the onset of the recession.

Going through a recession while keeping the exchange rate fixed is costly in terms of welfare. The capitalist experiences a drop of welfare equivalent to a 1.4 percent in permanent consumption. The average worker’s welfare drops by an equivalent permanent decrease of 1.7
percent of consumption in the steady state. However, not all workers experience the same effect on welfare. Non-employed workers, unemployed workers and those employed in the competitive sector at the onset of the recession lose the most on average. While the average welfare cost for unionized workers is lower, the median tradable and non-tradable unionized workers actually experience a welfare gain equivalent to a permanent increase in consumption between 0.4 and 0.6 percent. These patterns are explained by the heterogeneous dynamics of sectoral labor markets. Unionized employment decreases, but the median unionized worker remains employed. His welfare increase is due to the deflation experienced by the economy that allows him to afford higher consumption. Since unemployment increases, per capital real transfers decline which hurts non-employed workers. Unemployed workers also are worse off due to the lower probability of finding a unionized job. The reason why competitive workers are worse off is twofold. First, the probability of making a job-to-job transition to a unionized job decreases. Second, the real competitive wage declines to accommodate a larger inflow of workers.

Heterogeneous effects are also found when grouping workers in terms of asset quintiles and their idiosyncratic productivities. Welfare costs are found to be monotonically decreasing in assets, with average welfare costs ranging from 4 to 0 percent of permanent consumption. Asset-poor workers not only are more affected because their low levels of asset prevent them from smoothing consumption throughout the recession, but also because they are more likely to be non-employed or employed in the competitive sector. Similarly, the least productive workers experience the largest welfare cost because at the onset of the recession they are more likely to be non-employed. This means that they receive lower real transfers while remaining non-employed and that a fraction of them enter the labor market with depressed competitive real wages.

The negative welfare consequences can be avoided with a devaluation, if it does not affect the real value of assets and liabilities. A devaluation lowers the average welfare cost of a recession from an equivalent drop in permanent consumption of 1.7 to only 0.2 percent for workers, and from a drop of 1.4 to 0.5 percent for the capitalist. Furthermore, this gain is experienced by all types workers on average. However, the model predicts that the median unionized worker becomes worse off with the devaluation. Since for him the devaluation does not generate any employment gain, the decrease in the real unionized wages affects him negatively.

A large fraction of the gains that devaluations offer via the labor market can disappear when revaluation effects are taken into account. In the scenario in which the government increases its expenditures in non-tradable goods, the average worker experiences a welfare

\[ 34 \] Burnside et al. (2006) analyze the government financing of fiscal costs associated with currency crises in emerging markets. They find that, in addition to the decrease in the dollar value of government debt that I consider here, an additional source of government revenue is the decrease in the dollar value of government expenditures denominated in local currency (mostly government transfers).
loss equivalent to a permanent drop of 1.8 percent of steady state consumption. This cost is fairly close to the welfare cost experienced when the government decides to keep the exchange rate fixed. In this case, these costs are born mostly by asset rich workers. Part of those workers are non-employed at the onset of the recession (given that high levels of assets induce a worker not to work). However, the biggest losers are unionized workers once again. Relative to a scenario with a baseline devaluation, the reason for experiencing a welfare drop is twofold. First, because the devaluation decreases the real union wage, and second because unionized workers tend to accumulate more assets. This is also reflected in the large welfare drop of asset rich and more productive workers, which can reach up to an equivalent permanent drop of 4.4 percent of steady state consumption on average. The analysis also shows that the median unemployed and competitive workers are barely affected by revaluation effects and are likely to be in favor of the government devaluing the currency. These workers are the poorest in terms of assets, which isolates them from the effects of inflation on the real value of nominal assets.

Since the country is a net debtor, the devaluation generates a small welfare gain when it has revaluation effects and the government rebates the gain to non-employed workers. Relative to the previous scenario, the ranking of winner and losers is barely affected and the average worker in each group is better off. However, even if the government increases its transfers to workers, there are still groups of workers that are worse off with a devaluation. In particular, the median unionized worker and the median worker in the top quintile of the asset distribution would prefer to keep the exchange rate fixed.

The welfare results shown here differ from those presented in Schmitt-Grohé and Uribe (forthcoming). In their analysis, the authors develop a model with a representative household and aggregate shocks, which allows them to study the relationship between exchange rate policy and the average unemployment rate during the cycle. Part of the large welfare gains of a regime with a flexible exchange rate is due to the fact that it lowers the average unemployment rate of the economy. In this paper, I focus instead on identifying winners and losers from an unexpected devaluation. Although a large fraction of the average welfare cost of a recession can be avoided by devaluing the currency, my analysis shows that not all workers become better off. The consideration of additional revaluation effects on nominal positions makes the comparison of flexible regimes against fixed regimes less favorable.

The previous discussion focused on ex-post welfare effects of exchange rate policy. One of the conclusions of this analysis is that the median unionized worker becomes worse off with the devaluation. This is mostly due to the fact that the median unionized worker does not lose his job during the recession. An equally interesting question is whether workers are better or worse off from an ex-ante perspective. For example, it might be the case that unionized workers are ex-ante better off with the devaluation, that is, before uncertainty about who loses his job is
resolved. Ex-ante welfare effects are obtained by comparing the expected utility obtained in each scenario with the expected utility obtained in steady state. For ease of interpretation, welfare effects are presented as equivalent permanent changes of steady state consumption. This “behind the veil of ignorance” measure can be also used to answer another interesting question: if given the opportunity to express their preferences, would workers vote in favor or against a devaluation? While a formal analysis of the political economy process behind a devaluation is beyond the scope of this paper, the chosen ex-ante welfare measure is consistent with the outcome of a model of probabilistic voting (see Persson and Tabellini (2000)). In that model, the result of the election coincides with the policy that maximizes a weighted social welfare function similar to the one used here.

As can be seen from Table 12, the main result is that the outcome of an election would be in favor of a devaluation, independently on whether it entails revaluation effects or not. However, there are some scenarios in which a devaluation faces the opposition from some groups of workers. If the devaluation does not affect the real value of assets, it becomes a popular policy among all groups of workers defined in terms of their labor market status and the level of assets held at the onset of the recession. When the devaluation has revaluation effects and the government uses the additional resources to increase its expenditures on non-tradable goods, non-tradable unionized workers would vote against the devaluation (and the tradable unionized workers are close to being indifferent between the devaluation and a fixed exchange rate). By looking at the preferences of workers according to their position in the asset distribution we can measure the fraction of workers that would vote against a devaluation. Workers in the top two quintiles of the asset distribution would vote against the devaluation, which means that the opposition contains at least 40% of workers and the election would be closely contested.\footnote{Uncertainty about the relative sizes of both groups could make politicians delay the necessary adjustments. Indeed, the literature that studies political business cycles found that exchange rate devaluations intensify after elections (see Cermeño et al. (2010) and Stein and Streb (2004)).}

In the scenario in which the government increases transfers to non-employed workers, the devaluation faces a much lower opposition and only workers in the highest quintile of the asset distribution would vote against the devaluation. Thus, the conclusion from this analysis is that governments have room to adopt fiscal policies in order to obtain the support from a large fraction of the population when deciding whether to devalue the currency or not.
### Table 11. Welfare Effects of Exchange Rate Policy

<table>
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<th>Fixed Exchange Rate</th>
<th>Devaluation Baseline</th>
<th>Currency Mismatch Higher Govt. Spending</th>
<th>Currency Mismatch Higher Transfers</th>
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Notes: Welfare effects in each scenario expressed in equivalent change in permanent consumption that would make the worker indifferent between living throughout each scenario and living in an economy that remains in steady state. The disaggregation of workers’ welfare effects is done according to each worker’s state in the period before the shock hits the economy. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario.
### Table 12. Welfare Effects of Exchange Rate Policy behind the Veil of Ignorance

<table>
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<td>Unemployed</td>
<td>-2.4</td>
<td>-0.5</td>
<td>-0.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Trad. Union.</td>
<td>-2.1</td>
<td>-0.6</td>
<td>-2.1</td>
<td>-0.6</td>
</tr>
<tr>
<td>Non-Trad. Union.</td>
<td>-0.8</td>
<td>-0.3</td>
<td>-1.6</td>
<td>-0.8</td>
</tr>
<tr>
<td>Non-Trad. Comp.</td>
<td>-2.3</td>
<td>-0.4</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Workers: Asset Quintile</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>-2.9</td>
<td>-0.6</td>
<td>0.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Q2</td>
<td>-2.0</td>
<td>-0.5</td>
<td>-0.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Q3</td>
<td>-1.4</td>
<td>-0.4</td>
<td>-1.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Q4</td>
<td>-1.0</td>
<td>-0.2</td>
<td>-2.1</td>
<td>-0.8</td>
</tr>
<tr>
<td>Q5</td>
<td>-0.6</td>
<td>0.0</td>
<td>-4.2</td>
<td>-3.1</td>
</tr>
</tbody>
</table>

*Notes:* Welfare effects in each scenario expressed in equivalent change in permanent consumption that would make a worker behind the veil of ignorance indifferent between living throughout each scenario and living in an economy that remains in steady state. The disaggregation of workers’ welfare effects is done according to each worker’s state in the period before the shock hits the economy. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario.
6. Conclusion

In this paper I studied what happens to a labor market when a country devalues its currency. In particular, the analysis focused on understanding whether some workers gain or lose more than others and what are the determinants of such heterogeneous effects. Is it about the way the labor market in different sectors work? What role does the redistribution of wealth across agents play? The analysis focused on two channels through which a nominal devaluation affects the real economy. First, the combination of nominal wage rigidities and a fixed exchange rate leads to real wage rigidities. Then, a negative aggregate demand shock inevitably affects the demand for labor. In this situation, it might be worth considering to decrease wages in real terms via a nominal devaluation. However, if not all wages are equally rigid, sectoral labor markets respond differently to the same shock in terms of employment and equilibrium real wages. Second, nominal devaluations could have revaluation effects on the real value of households nominal positions. Then, these revaluation effects can outweigh the gain in employment generated by the devaluation.

This paper presented a multi-sector small open economy model with different degrees of downward nominal wage rigidities across sectors and heterogeneous workers. The model was estimated by the simulated method of moments so that the steady state equilibrium predictions of the model match several micro- and macro-moments of the Argentinian economy during the years before the recession. In particular, I targeted several moments that reflect workers choices, for example, the fraction of workers in each labor market status, wage differentials across sectors and transition rates across all labor market status.

The main quantitative result is that devaluations entail substantial redistribution of welfare. If devaluations do not affect the real value of nominal positions, the model predicts that the devaluation reduces the average welfare cost of a recession relative to keeping the exchange rate fixed. Despite the average worker being better off, devaluations do benefit a group of workers at the expense of others. Also, I find revaluation effects to be strong enough to overcome the labor market gain from this policy.
References


Appendix A. Additional Empirical Evidence

A.1. Evolution of Nominal and Real Wages by Groups of Workers

One might be concerned about compositional effects driving the heterogeneity in the degree of nominal wage rigidities across sectors. Figure A.1 shows the evolution of nominal and real wages controlling for workers’ observable characteristics. More specifically, I regress the log nominal and real wage of each worker on a set of controls such as age, educational attainment, gender, tenure, and dummies for industry and time. The figure plots the series of time dummies obtained from this regression. The general pattern is replicated once I take into account observable heterogeneity. The results also show that a small fraction of the observed rigidity in nominal unionized wages is explained by compositional effects. However, the average percent decrease in unionized nominal wages is 0.9% per quarter, which is consistent with the degree of wage flexibility allowed in the model.

Figure A.1. Nominal and Real Hourly Wages with Controls

(A) (Log) Nominal Hourly Wage of Workers  
(B) (Log) Real Hourly Wage of Workers

Notes: Panel (A) and (B): (log) average nominal and real hourly wage in main occupation for skilled workers (from incomplete college education to complete college education), respectively. Panel (A) and (B): (log) average nominal and real hourly wage in main occupation for un-skilled workers (from no education to completed secondary education), respectively. Data source: Argentinian Household Survey. The sample includes all male and female workers between 25 and 60 years old. See Appendix C.1 for details. Series constructed using seasonally adjusted quarterly data. Missing values have been imputed with ARIMA model.

A.2. The Role of Union Bargaining

One of the main assumptions made in the paper is that downward nominal wage rigidities are caused by frictions in the bargaining problem between unions and firms. This section briefly describes the union system in Argentina (which is in general terms similar to the European union system) and, more importantly, presents supporting evidence to this assumption.
The Argentinian union system is characterized by a high degree of centralization, by which a single union is given the monopoly power by law to represent workers within a specific industry, branch of activity, or type of occupation, irrespective of whether the worker is an union member or not. Nonetheless, there are certain groups of workers of the economy that are excluded from the collective bargaining process. Legally, these are the public sector workers, workers from the agricultural sector and private sector teachers, whose wages are all determined by other mechanisms. In practice, we also need to exclude non-registered/informal workers, whose work legal status makes them less likely to be covered by the collective agreements, and self-employed workers. Also, unions tend to negotiate the wages of blue-collar workers and the lower ranks of white-collar workers. Thus, wages of employees in administrative and managerial jobs are usually not covered by union collective bargaining, and are more subject to competitive forces. Just as an illustration of how extensive and centralized this collective bargaining agreement is, in 2006 the wages of more than 80% of the private-sector formal employees were determined within the collective bargaining process (MTESS (2096)). Similarly, the 30 largest unions represent around 75% of the private-sector formal employees whose wages are determined in collective agreements, and only 15 collective agreements represent over 50% of these workers. Furthermore, the union has the power to negotiate collective agreements at different levels of representation, starting from firm-level agreements and extending to industry-wide agreements in which all the workers represented by the union are covered by the agreement.

Suggestive evidence of the effects of unions’ behavior on the degree of downward nominal wage rigidities is presented in Figure A.2, which shows the number of contracts negotiated by unions and firms in 12 sectors between 1995 and 2008. The figure distinguishes between contracts signed between an union and a single firm and those signed between an union and representatives of the entire industry. The source of these data are the original documents signed by the parties in each collective bargaining contract approved by the Argentinian Ministry of Labor. The sample of contracts includes only contracts that modified the scale of basic wages of workers. Usually, these contracts specify a scale of basic wages for workers with different occupations and tenure. These scales of basic wages define the wage over which workers pay taxes and social security contributions, and exclude non-taxable additional labor income (such as additional income for newborn child, travel expenses, etc). The general pattern that emerges across sectors is that in the years that led to the recession the overall collective bargaining process was rather weak, and more frequent and extensive thereafter. This explains the relatively constant average wage of formal workers during the recession.
period. This is particularly true for contracts negotiated at the industry level, which tend to cover a larger fraction of the formal labor force.

Figure A.2. Number of Union Contracts Signed by Month and Industry

Notes: This figure shows the monthly number of contracts negotiated by unions and firms in 12 sectors between 1995 and 2008. The figure distinguishes between contracts signed between an union and a single firm, and those contracts signed between an union and representatives of the industry. Data source: Ministry of Labor.

Appendix B. Numerical Solution Method

B.1. Recursive Worker Problem

The worker’s problem admits a recursive representation. The state space of the worker consists of his previous sector of employment $s_{-1}$, his current labor market status $s$, the level of bond holdings $b_{it}$ and the level of idiosyncratic productivity $z_{it}$. The value of a worker

Before 2002, the Argentinian law allowed expired contracts to remain valid until a new contract was signed by the union and the firms. The result of this law was that during the 1990s a large proportion of the wages remained determined by contracts negotiated at the beginning of the decade that weren’t renegotiated after their expiration.
employed in sector \( s \in \{T, NU, NC\} \) in period \( t \) is given by

\[
V_t^s(z_{it}, b_{it}) = \max_{C_{it}^T \geq 0, C_{it}^N \geq 0, b_{it+1} \geq 0} u(C_{it}^T, C_{it}^N) + \beta \gamma \left[ u(C_{it+1}^T, C_{it+1}^N) \right] + \beta (1 - \gamma) \left( \psi^s \mathbb{E}_{\epsilon_{it+1}, z_{it+1}}\left[ V_{t+1}^0(z_{it+1}, b_{it+1}, s) + \epsilon_{it+1}^0 \right] \right) \\
+ (1 - \psi^s) \mathbb{E}_{\epsilon_{it+1}, z_{it+1}}\left[ \sum_{s' \neq \{0, s\}} n_{s,s'} \max_{s''=\{0, s'\}} \left\{ V_{t+1}^{s',s''}(z_{it+1}, b_{it+1}) + \epsilon_{it+1}^{s''} \right\} \right]
\]

subject to

\[
P_t^T C_{it}^T + P_t^N C_{it}^N + \frac{E_t b_{it+1}}{1 + R} \leq (1 - \tau^s) w_t^s z_{it} + E_t b_{it},
\]

where

\[
V_{t}^{s', s''}(z_{it}, b_{it}) = q_{t}^{s', s''} V_{t}^{s''}(z_{it}, b_{it}) + (1 - q_{t}^{s', s''}) V_{t}^{0}(z_{it}, b_{it}, s) - t \mathbb{1}\{s' \neq 0\}
\]

This value is given by the current utility of consumption and the continuation value. With probability \( \gamma \) the worker dies, does not work and consumes all the accumulated bonds. Conditional on surviving, the worker is exogenously separated with probability \( \psi^s \) and becomes non-employed. With probability \( 1 - \psi^s \) the workers is not separated and can choose whether to continue working in the same sector, apply for a job in another sector (if given the opportunity) or become non-employed. Similarly, the value of non-employment is given by

\[
V_t^0(z_{it}, b_{it}, s) = \max_{C_{it}^T \geq 0, C_{it}^N \geq 0, b_{it+1} \geq 0} u(C_{it}^T, C_{it}^N) + \beta \gamma \left[ u(C_{it+1}^T, C_{it+1}^N) \right] + \beta (1 - \gamma) \left( \lambda^s \mathbb{E}_{\epsilon_{it+1}, z_{it+1}}\left[ \max_{s'} V_{t+1}^{0,s'}(z_{it+1}, b_{it+1}) + \epsilon_{it+1}^{s'} \right] \right) \\
+ (1 - \lambda^s) \mathbb{E}_{\epsilon_{it+1}, z_{it+1}}\left[ \max_{s''=\{0, s\}} \left\{ V_{t+1}^{0,s''}(z_{it+1}, b_{it+1}) + \epsilon_{it+1}^{s''} \right\} \right]
\]

subject to

\[
P_t^T C_{it}^T + P_t^N C_{it}^N + \frac{E_t b_{it+1}}{1 + R} \leq T_t + E_t b_{it},
\]

where

\[
V_{t}^{0, s'}(z_{it}, b_{it}) = n_{0,s'} q_{t}^{0, s'} V_{t}^{s'}(z_{it}, b_{it}) + (1 - n_{0,s'} q_{t}^{0, s'}) V_{t}^{0}(z_{it}, b_{it}, s) - t \mathbb{1}\{s' \neq 0\}
\]
This value is given by the current utility of consumption and the continuation value. The continuation value conditional on surviving is given by the expected value of the choice between staying non-employed and searching for a job.

In order to keep the model tractable I assume that $\epsilon_i t$ follows a type 1 Extreme Value distribution with location parameter $0.5772 \sigma_e$ and scale parameter $\sigma_e$. I further assume that preference shocks are independently distributed across workers, time and sectors. The benefit of making this particular distributional assumption is that the expectations with respect to the vector of shocks $\epsilon_i t$ have the following closed form solutions (see McFadden (1974) for a derivation of this result):

$$V^s_t(z_i t, b_i t) = \max_{C^T_{i t} \geq 0, C^N_{i t} \geq 0, b_{i t+1} \geq 0} u \left( C^T_{i t}, C^N_{i t} \right) + \beta \gamma \left[ u \left( C^T_{i t+1}, C^N_{i t+1} \right) \right]$$

$$+ \beta(1 - \gamma) \left( \psi^s \mathbb{E}_{z_{i t+1}} \left[ V^0_t(z_{i t+1}, b_{i t+1}, s) \right] \right)$$

$$+ (1 - \psi^s) \mathbb{E}_{z_{i t+1}} \left[ \sum_{s' \neq \{0, s\}} n^{s,s'} \sigma \log \left\{ \sum_{s'' \neq \{0, s, s'\}} \exp \left( V^{s,s''}_{t+1}(z_{i t+1}, b_{i t+1}) / \sigma_e \right) \right\} \right]$$

and

$$V^0_t(z_i t, b_i t, s) = \max_{C^T_{i t} \geq 0, C^N_{i t} \geq 0, b_{i t+1} \geq 0} u \left( C^T_{i t}, C^N_{i t} \right) + \beta \gamma \left[ u \left( C^T_{i t+1}, C^N_{i t+1} \right) \right]$$

$$+ \beta(1 - \gamma) \left( \lambda^s \mathbb{E}_{\epsilon_{i t+1}, z_{i t+1}} \left[ \sigma \log \left\{ \sum_{s'} \exp \left( V^{0,s'}_{t+1}(z_{i t+1}, b_{i t+1}) / \sigma_e \right) \right\} \right] \right)$$

$$+ (1 - \lambda^s) \mathbb{E}_{\epsilon_{i t+1}, z_{i t+1}} \left[ \sigma \log \left\{ \sum_{s' \neq \{0, s\}} \exp \left( V^{0,s'}_{t+1}(z_{i t+1}, b_{i t+1}) / \sigma_e \right) \right\} \right]$$

Furthermore, this distributional assumption also allows for a closed form expression of transition probabilities across states. For example, the proportion of workers that were not employed in period $t - 1$, are given the opportunity to search for a job in any sector and choose sector $s'$ in period $t$ is given by

$$p^{0,s'}_{t}(z_i t, b_i t) = \frac{\exp \left( V^{0,s'}_{t}(z_i t, b_i t, s) / \sigma_e \right)}{\sum_{s''} \exp \left( V^{0,s''}_{t}(z_i t, b_i t, s) / \sigma_e \right)}.$$
B.2. Algorithm for Solution of Steady State

The steady state model is solved by fixing $A_s = 1$ for all $s$ and $E_t = 1$. The solution involves guessing values for a subset of equilibrium objects, computing the optimal policies and values for each economic agent and the ergodic distribution of workers and checking whether equilibrium conditions hold at the guessed values. The ergodic distribution of workers is computed via the non-stochastic simulation method of Young (2010) and the market clearing objects are computed via the iteration-over-allocation method of (Maliar et al. (2011)). The full algorithm that computes the steady state of the model is as follows:

**Step 1:** Set the initial guess of equilibrium intermediate goods prices $(P^{NU}, P^{NC})$, wages in competitive sectors $w^{NC}$, job rationing probabilities in unionized sectors $q^{s,s'}$ and per capita transfers for non-employed workers $T$.

**Step 2:** For $s \in \{T, NU\}$ solve the bargaining problem. Since in steady state there are no capital adjustment costs and no nominal rigidities, this step involves maximizing the geometric averages of the firm’s current net profits and union’s net flow utility.

**Step 3:** Compute capitalist’s optimal choices. Compute labor demand and investment of the firm operating in the competitive sector. These are simply obtained from the first order conditions with a Newton solver.

**Step 4:** Solve the problem of the worker for all combinations of the worker’s state space $(b, z, s_{-1}, s)$. I discretize both continuous variables $b$ and $z$. The grid for $b$ has 45 points and is unequally spaced, containing more grid points close to zero (where the value functions exhibits higher curvature) with a specific point at $b = 0$. For worker’s (log) idiosyncratic productivity I construct a grid vector with 11 points equally spaced on the interval $[-2\sigma_z/\sqrt{1 - \rho_z^2}, 2\sigma_z/\sqrt{1 - \rho_z^2}]$ following the method presented in Tauchen (1986). The value function is interpolated linearly in the $b'$ and $z'$ directions. The optimization is performed at each grid point until the iteration over the Bellman equations converges to a specified tolerance level in the order of magnitude of $10^{-6}$.

**Step 5:** Given the value and policy functions computed in the previous step I use the non-stochastic simulation method of Young (2010) to compute the workers’ ergodic distribution. For this step I increase the number of grid points in the $b$ direction to 251. The details of the simulation are as follows:

(1) Initialize the distribution of workers by distributing a unit mass of workers evenly across possible states $(z, b, s_{-1}, s)$.

(2) Update forward the steady state distribution of workers $x(z, b, s_{-1}, s)$. In order to do this I compute sectoral transition probabilities and the optimal savings policy for each combination of the vector $(z, b, s_{-1}, s)$ by linearly interpolating the value and policy functions obtained in Step 4. Most likely the optimal savings policies $b' = b(z, b, s_{-1}, s)$ do not fall in a grid point of the distribution of workers. In that case the mass is linearly
split between the points in the grid that satisfy $b(z,b,s_{-1},s) \in [b_j, b_{j+1}]$ (where $j$ denotes a grid point) and the weights are given by the distance between $b(z,b,s_{-1},s)$ and each of those two points.

(3) Iterate on step (2) until the distance between the distributions $x$ and $x'$ is below a specified tolerance level in the order of magnitude of $10^{-9}$.

**Step 7:** Compute the aggregate level of workers’ assets and the aggregate sectoral labor supply using the ergodic distribution obtained in the previous step.

**Step 8:** Evaluate the residuals of the equilibrium conditions that require market clearing in the intermediate goods markets and in the competitive labor market, guessed job rationing probabilities in unionized sectors to satisfy equations (8) and (9), guessed competitive wage to equalize labor demand and supply and guessed transfers to satisfy the budget constraint of the government. If the maximum relative error across all equilibrium conditions is smaller than $10^{-5}$, stop the algorithm. Otherwise, update the guess and return to Step 2.

B.3. Algorithm for Solution of Transition Dynamics

The solution algorithm of the model’s transition dynamics after an unexpected shock is similar to the algorithm described in Section B.2. Here I discuss the main differences. In all the model experiments I consider I study the effects of pure transitory shocks. Thus, the dynamics of the model are such that the steady state real allocations must be approximately reached at period $T$, for $T$ large enough. The algorithm that computes the transition dynamics of the model is as follows:

**Step 0:** Define grids of current capital and past wages for the bargaining problem, grids of current capital for the problem of competitive firms and grids of current bonds for the capitalist’s problem. These grids are constructed within a given range with respect to the corresponding value in steady state. Fix a value for $T$ large enough so that the value of the transitory shocks and the (real) value of endogenous objects are back to their steady state level by period $T$. Compute the sequence of transitory shocks to the TFP in the tradable sector and define the vector of exchange rates from $t = 1$ to period $t = T$.

**Step 1:** Guess initial sequences of equilibrium intermediate goods prices $\{P_{t}^{NU}, P_{t}^{NC}\}_{t=1}^{T}$, wages in the competitive sector $\{w_{t}^{NC}\}_{t=1}^{T}$, job rationing probabilities in unionized sectors $\{q_{t}^{s,s'}\}_{t=1}^{T}$, per capita government transfers $\{T_{t}\}_{t=1}^{T}$ and capitalist’s discount factor $\{\Lambda_{t,t+1}\}_{t=1}^{T}$. In the first iteration of the algorithm I initialize all these sequences equal to their corresponding steady state values.

**Step 2:** Solve the problem of each economic agent from period $t = 1$ to period $t = T$ by assuming that at period $T+1$ the economy has converged to the steady state and by computing the optimal values and policies backwards from $t = T$ to $t = 1$. Whenever it is necessary I interpolate policy and value functions linearly in the desired direction.
Step 3: Given the value and policy functions computed in the previous step I simulate each agent’s decisions forward from period $t = 1$ to period $t = T$. I set the starting values for the firm’s capital, past wages negotiated in the unionized sectors and the level of capitalist’s assets to the corresponding steady state values. Also, I set the distribution of workers at period $t = 0$ equal to the steady state distribution of workers. For the bargaining problem, the problem of the intermediate good producers and that of the capitalist the simulation is done by interpolating the optimal policies found in the previous step. The distribution of workers is simulated using the method proposed by Young (2010) and described in Section B.2. The only difference is that the updated distribution corresponds to the distribution of workers at period $t + 1$.

Step 4: Evaluate the series of residuals of the equilibrium conditions described in Step 8 of Section B.2. If the maximum relative error across all equilibrium conditions and across all periods is smaller than $10^{-5}$, stop the algorithm. Otherwise, update the guessed sequences and return to Step 2.

Step 5: Once the algorithm converged verify that the model has approximately reached the steady state in period $T$. If not, increase $T$ and return to Step 1.

Appendix C. Quantitative Appendix

C.1. Data, Sample Selection and Construction of Moments

The main source of micro-data is the Permanent Household Survey (Encuesta Permanente de Hogares, hereafter EPH), which is the main household survey in Argentina. It covers 31 large urban areas with an estimated representativeness of more than 60% of total population. In any given year the total sample size is around 100,000 households and the average response rate is in the order of 90% (which is similar to the US CPS survey). The questionnaire contains extensive information of labor market participation (hours worked, labor income, tenure, industry of occupation, etc.) and demographics (level of education, age, etc.).

Until 2003 the EPH was conducted twice a year (once in May and once in October). In this version of the survey only 25% of the surveyed households were replaced across semesters, which implies that 75% of the sample could be followed over a 6 months period, 50% over a year and 25% over a year and a half. Since 2003 the survey has been conducted on a quarterly basis and the rotation scheme was modified. Households are interviewed for two consecutive quarters, rotate out for two quarters and then rotate in for two additional quarters. Given these changes I decided to compute transition rates on an annual basis in order to maximize the sample size and to guarantee consistency over time (also these changes prevent me from computing transition rates between 2002 and 2003).

The sample used to compute the micro-moments used in the estimation consists of all households that completed the EPH between 1995 and 1999 (since these data are used to
discipline the parameters of the model in steady state I exclude observations from the recession period). I include all men and women between 25 to 60 years old\(^{38}\) that were classified as either employed, unemployed or out of the labor force (if the workers is classified as employed but he actually works as a part of a workfare program I classify him as unemployed). In terms of geographical coverage, I keep observations from areas that were surveyed during the entire period of analysis (this drops observations from 3 small areas). Within the group of employed individuals, I drop all self-employed and business owners and keep only individuals who work as employees. The reason is that the earnings of self-employed and owners include returns to other productive factors, which cannot be compared directly to the earnings of employees, and also because the EPH does not allow these individuals to be classified as formal or informal. Similarly, I drop unemployed individuals that had previous employment either as self-employed or employer.

With this final sample in had I classify employed individuals in 3 categories: tradable, non-tradable unionized and non-tradable competitive. The distinction of the industry of occupation by tradable and non-tradable was made using the ISIC Rev. 3 classification method. Tradable sectors are: Agriculture, hunting and forestry, Fishing, Mining and quarrying, and Manufacturing. Non-tradable sectors are: Electricity, gas and water supply, Construction, Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods, Hotels and restaurants, Transport, storage and communications, Financial intermediation, Real estate, renting and business activities, Public administration and defense; compulsory social security, Education, Health and social work, Other community, social and personal service activities, Private households with employed persons and Extra-territorial organizations and bodies. In order to classify employed individuals between unionized and competitive I use the formal and informal distinction. This is done by following a standard definition of informality proposed by International Labour Organization and found elsewhere in the literature. The formal/informal classification is made on the basis of lack of compliance with labor legislation. More specifically, I use the lack of social security contributions by the employer as the classification criterion. Thus, workers whose employer does not make social security contributions are classified as informal/competitive.

Finally, the measure of labor income used in the analysis corresponds to the real hourly wage\(^{39}\) in the main occupation. The focus on the main occupation is relatively innocuous since more than 90% percent of all employees have exactly one occupation. Further, the

\(^{38}\) The reason for making this decision is that by the age of 25 most of the educational decisions has been made for the majority of individuals and because 60 years old it is the legal retirement age for women in Argentina.

\(^{39}\) The average inflation is computed with INDEC data up until 2007. After then the official measure of inflation stops being trustworthy and the average inflation is taken from taking an average of alternative private measures. See Drenik and Perez (2014) for an explanation of the manipulation of the official CPI figures and for the use of alternative measures of CPI in Argentina for that period.
mean number of occupations and the fraction of employees with more than one occupation is similar between the formal and informal labor market. In order to avoid the effect of outliers I consider employees that during the week of reference have worked between 20 and 60 hours and also real hourly wages that are within the 10-90 range of the overall distribution. All statistics were computed using sampling weights provided by the survey.

C.2. Estimation of Idiosyncratic Wage Process

As explained in the previous section, since 2003 the structure of the EPH is such that workers are surveyed in two consecutive quarters, then dropped from the sample for two quarters and finally interviewed again for two additional consecutive quarters. This allows me to apply the methodology presented in Floden and Lindé (2001) to estimate the wage process (3) using observations from workers that were continuously employed in the unionized and competitive sector during the sampling window. The fact that the estimation is carried out with the subsample of workers that have decided to work is not an issue, since the model takes into account the selection process and the estimates from the model follow the same sampling scheme.

Let \( \ln W_{it} = w_{it} \) denote the observed log real hourly wage for a worker \( i \) at period \( t \). Wages are assumed to be determined by the following process

\[
\begin{align*}
    w_{it} &= \chi X_{it} + \log z_{it} + \nu_{it} \\
    \log z_{it} &= \rho_z \log z_{it-1} + \varepsilon_{it}
\end{align*}
\]

where \( \nu_{it} \) is the measurement error component distributed \( iid \) with zero mean and variance \( \sigma_{\nu} \). The vector \( X_{it} \) includes a set of control variables at the individual level (\( age_{it}, \ age_{it}^2, \ tenure_{it}, \ education_{it}, \) etc.) and a set of aggregate time dummies. The estimation procedure consists of two steps. In the first step I regress \( w_{it} \) on \( X_{it} \) using observations from workers that were employed in the unionized or competitive sector, separately. The estimation results are used to compute the net real hourly wage

\[
\hat{w}_{it} = w_{it} - \hat{\chi} X_{it}
\]

In the second step of the estimation we use this residualized wage to estimate the idiosyncratic AR(1) component by GMM. In order to identify the persistence parameter \( \rho_z \), the variance of idiosyncratic shocks \( \sigma_z \) and the variance of the measurement error component \( \sigma_{\nu} \) we use observations from workers that were continuously employed to construct the following moment conditions

\[40\] Given that this scheme allows me to track the evolution of wages in the short run, the estimation of the idiosyncratic wage process uses data from 2003 to 2011.
\[
\mathbb{E} \left( \left( \hat{w}_{it} \right)^2 \right) - \frac{\sigma_z^2}{1 - \rho_z^2} - \sigma_v^2 = 0
\]

\[
\mathbb{E} \left( \hat{w}_{it} \hat{w}_{it-l} \right) - \rho_z \frac{\sigma_z^2}{1 - \rho_z^2} = 0
\]

for lags \( l = \{1, 4\} \). The GMM estimates are presented in Table A.1. The results show that idiosyncratic wages are equally and highly persistent in both sectors. The estimated values are similar to the ones presented in Floden and Lindé (2001) (when converted to a quarterly basis).

In the model there is a single process for labor market productivity that does not depend on the current sector of employment. An alternative model would be:

\[
\log z_{ijt} = \rho_j \log z_{it} - 1 + \varepsilon_{ijt},
\]

where \( j \) denotes a unionized or a competitive sector and the vector \( \varepsilon_{ijt} \) is allowed to be contemporaneously correlated across \( j \). The reason for not considering this process is twofold. First, when estimating Equation (13) using only workers that remained employed in the unionized or competitive sector in all periods, the autocorrelation is similar across labor markets. Second, the estimated correlation of shocks \( \varepsilon_{ijt} \) (using workers that made a transition between the unionized and the competitive sector) is relatively high (0.65).

Table A.1. GMM Estimation of Idiosyncratic Wage Process

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unionized</th>
<th>Competitive</th>
<th>Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho )</td>
<td>0.9696 (0.0052)</td>
<td>0.9653 (0.0223)</td>
<td>0.9697 (0.0069)</td>
</tr>
<tr>
<td>( \sigma_w )</td>
<td>0.0819 (0.0069)</td>
<td>0.1110 (0.0399)</td>
<td>0.0911 (0.0129)</td>
</tr>
<tr>
<td>( \sigma_v )</td>
<td>0.1168 (0.0014)</td>
<td>0.1819 (0.0060)</td>
<td>0.1397 (0.0037)</td>
</tr>
</tbody>
</table>

Notes: This table presents the estimates of Equation (13) using three different samples. The first two columns include only workers that remained employed in the unionized and competitive sectors in all periods, respectively. The last columns pools all workers together. Block bootstrapped standard errors.

C.3. Goodness of Fit

Figure A.3 presents the distribution of the length of unemployment spell for unemployed workers by previous sector of employment. In the data approximately 20% of unemployment spells of workers that were previously employed in the unionized sectors last 5 or more quarters, as opposed to only 20% of spells of unemployed workers coming from the competitive sector. Similarly, 50% of unemployment spells of workers with a previous competitive job last for a single quarter. While the overall pattern is matched by the model, the model fails to generate a lower fraction of short-term spells in the case of workers coming from the unionized sectors. In the model there is a fraction of unionized workers with relatively low idiosyncratic
productivity that keep working only because of the higher wage per unit of efficiency labor. When those workers get separated, they are closer to the threshold that makes them decided not to participate in the labor market. This reflects itself in a higher fraction of short-lived unemployment spells of workers coming from the unionized sector.

Figure A.4 shows the distribution of the unemployment rate by sector of previous employment. It shows that in addition to fitting the aggregate unemployment rate, the model is able to capture “sector-specific” unemployment rates. Finally, Table A.2 shows transitions rates of workers that undergo a spell of unemployment from the previous to the new labor market status. As it was previously mentioned, the model has problems replicating the transitions of unionized workers after an unemployment spell (the fraction of unionized workers going into non-participation is too large relative to the same fraction of competitive workers).

**Table A.2. Return Probabilities (%): Pre-Crisis Period**

<table>
<thead>
<tr>
<th>Panel A: Data</th>
<th>Non-Participation</th>
<th>Unemp.</th>
<th>Tradable</th>
<th>Non-Tradable</th>
<th>Non-Tradable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tradable Union.</td>
<td>22.0</td>
<td>34.3</td>
<td>10.9</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>Non-Tradable Union.</td>
<td>27.2</td>
<td>29.0</td>
<td>1.0</td>
<td>18.6</td>
</tr>
<tr>
<td></td>
<td>Non-Tradable Comp.</td>
<td>33.1</td>
<td>28.8</td>
<td>1.7</td>
<td>8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Model</th>
<th>Non-Participation</th>
<th>Unemp.</th>
<th>Tradable</th>
<th>Non-Tradable</th>
<th>Non-Tradable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tradable Union.</td>
<td>32.7</td>
<td>25.2</td>
<td>7.8</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Non-Tradable Union.</td>
<td>35.5</td>
<td>27.9</td>
<td>0.8</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>Non-Tradable Comp.</td>
<td>26.6</td>
<td>20.7</td>
<td>5.9</td>
<td>5.6</td>
</tr>
</tbody>
</table>

*Notes: The table shows one-period ahead transition rates across all possible labor market statuses. Rows correspond to the sector of previous employment and columns refer to status of destination. The sample is restricted to workers currently unemployed. The top panel corresponds to moments computed using micro data from Argentinian household survey between 1995 and 1999. The bottom panel refers to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.*
Figure A.3. Distribution of Length of Unemployment Spells by Previous Sector of Employment

Notes: The figure shows the distribution of the length of unemployment spells by previous sector of employment. Bins are expressed in quarters. Bars in blue correspond to moments computed using micro data from Argentinian household survey between 1995 and 1999. Bars in red refer to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.

Figure A.4. Distribution of Previous Sector of Employment of Currently Unemployed Workers

Notes: The figure shows the distribution of aggregate unemployment by previous sector of employment. Bars in blue correspond to moments computed using micro data from Argentinian household survey between 1995 and 1999. Bars in red refer to equivalent moments computed using the model predictions in the steady state equilibrium and by simulating a sample of 100,000 workers.

C.4. The Relationship Between Parameters and Moments

Figure A.5 presents a numerical approximation of the Jacobian associated with the estimation procedure. Each cell in the matrix represents the derivative of each moment (rows) with respect to each estimated parameter (columns), reported as an elasticity. These matrices are informative about which moments are more affected by changes in the value of certain parameters.
Notes: The figure plots the gradient of a set of targeted moments used in the SMM estimation. For ease of reference, the derivative of each moment with respect to the vector of model parameters are reported as elasticities of the moment to the set of parameters. In order to make the figure more informative, the elasticities have been censored at levels of +/- 2%. The moments included in this figure are: wage differentials across sectors, parameters of the AR(1) idiosyncratic productivity, distribution of workers by labor market status.
Notes: The figure plots the gradient of a set of targeted moments used in the SMM estimation. For ease of reference, the derivative of each moment with respect to the vector of model parameters are reported as elasticities of the moment to the set of parameters. In order to make the figure more informative, the elasticities have been censored at levels of $\pm 2\%$. The moments included in this figure correspond to the entire set of annual transition rates among all possible labor market states. $NP$ denotes non-participation, $T$ denotes the tradable-unionized sector, $NU$ denotes the non-tradable unionized sector, $NC$ denotes the non-tradable competitive sector and $U$ denotes unemployment.
Notes: The figure plots the gradient of a set of targeted moments used in the SMM estimation. For ease of reference, the derivative of each moment with respect to the vector of model parameters are reported as elasticities of the moment to the set of parameters. In order to make the figure more informative, the elasticities have been censored at levels of +/- 2%. The moments included in this figure correspond to: the distribution of tenure by sector of employment (labeled \textit{Tenure}), the distribution of the length of unemployment spells by sector of previous employment (labeled \textit{U.Length}), the distribution of unemployment by sector of previous employment (labeled \textit{Share}) and the fraction of workers that return to the same sector of previous employment after an unemployment spell (labeled \textit{Return}).
Appendix D. Welfare Effects as a Function of Devaluation Rates

In the body of the paper I consider the welfare effects of an increase in the nominal exchange rate of 200%, similar in magnitude to the devaluation observed in Argentina. Here, I present the welfare effects of a nominal devaluation as a function of the nominal exchange rate and consider devaluation rates that go in the range between 0% to 100%. The mechanisms described in the paper still prevail, the question I want to analyze here is how the relative importance of each effect is affected by the magnitude of the devaluation. Figure A.6 presents the aggregate ex-post welfare effects for workers and the capitalist. The blue line (baseline devaluation) shows that with a devaluation rate of around 20% the economy would have evolved as an economy with flexible wages. Devaluations of higher magnitude do not have any real effects.

If devaluations also affect the real value of assets and liabilities, then devaluations are always welfare improving for the capitalist, whose liabilities decrease in real terms. The aggregate welfare of workers depends on the fiscal policy implemented by the government. If the government spends the windfall gain in non-tradable goods, there is an optimal devaluation rate after which workers’ welfare is decreasing in the magnitude of the devaluation. On the other hand, if the government rebates the gain to non-employed workers, then aggregate welfare is increasing in the rate of devaluation since it increases the amount of transfers that workers receive.

Figure A.7 presents the welfare effects for different types of workers. The left (right) column splits workers according to their labor market status (level of assets) in the period before the economy is hit by the shock. The main results obtained with a large devaluation still prevail when I consider smaller devaluations. From an ex-post perspective, the welfare of the median unionized worker is a decreasing function of the devaluation rate. On the other hand, in almost all scenarios, the median welfare of non-unionized workers is increasing in the magnitude of the devaluation rate. Also, if devaluations have revaluations effects, the welfare of the median worker in the highest quintile is strictly decreasing in the size of the devaluation. These negative effects disappear for workers in the lowest asset quintile, and their welfare become an increasing function of the devaluation rate.

Finally, I have argued that idiosyncratic uncertainty plays a big role on determining whether workers would vote in favor or against a devaluation. Figures A.8 and A.9 present the welfare effects from an ex-ante perspective (i.e., under the veil of ignorance). The main difference is that unionized workers are in favor of devaluations as long as they are small in magnitude.

\[41\] The only exception is the welfare of the median worker that decided not to participate in the scenario in which the government increases expenditures in non-tradable goods. This is because one of the reasons to drop out of the labor force is a high level of savings. So, a fraction of these workers are negatively affected by the revaluation of its nominal savings.
The reason is that devaluations prevent unionized workers from losing their jobs, which is an uncertain event. However, even from an ex-ante perspective, there are still a fraction of asset-rich workers that become worse-off when the magnitude of the devaluation is large enough. Although the welfare effects by asset quintile are mechanical, they are not trivial. They show that the effects devaluations have via the labor market (i.e., undo the effects of nominal rigidities) are not compensated by their effects on the real value of savings. In other words, it is not the case that workers that benefit from one mechanism are negatively affected by the other, so that they are relatively indifferent about exchange rate policy.

**Figure A.6.** Aggregate Welfare Effects as a Function of the Devaluation Rate

Notes: Welfare effects in each scenario expressed in equivalent change in permanent consumption that would make an agent indifferent between living throughout each scenario and living in an economy that remains in steady state. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario. The left panel shows the median welfare effect of a nominal devaluation for workers and the right panel shows the effect for the capitalist. The welfare effects are computed for a range of devaluation rates from a fixed exchange rate (0% devaluation rate) to a devaluation rate of 100%.
Notes: Welfare effects in each scenario expressed in equivalent change in permanent consumption that would make a worker indifferent between living throughout each scenario and living in an economy that remains in steady state. The disaggregation of workers’ welfare effects is done according to each worker’s state in the period before the shock hits the economy. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario. The welfare effects are computed for a range of devaluation rates from a fixed exchange rate (0% devaluation rate) to a devaluation rate of 100%.
Figure A.8. Aggregate Welfare Effects behind the Veil of Ignorance as a Function of the Devaluation Rate

Notes: Welfare effects in each scenario expressed in equivalent change in permanent consumption that would make a worker behind the veil of ignorance indifferent between living throughout each scenario and living in an economy that remains in steady state. The disaggregation of workers’ welfare effects is done according to each worker’s state in the period before the shock hits the economy. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario. The welfare effects are computed for a range of devaluation rates from a fixed exchange rate (0% devaluation rate) to a devaluation rate of 100%.
Figure A.9. Workers’ Welfare Effects behind the Veil of Ignorance as a Function of the Devaluation Rate

Notes: Welfare effects in each scenario expressed in equivalent change in permanent consumption that would make a worker behind the veil of ignorance indifferent between living throughout each scenario and living in an economy that remains in steady state. The disaggregation of workers’ welfare effects is done according to each worker’s state in the period before the shock hits the economy. The distribution has been computed by simulating 100,000 workers after solving the transition dynamics of the model in each scenario. The welfare effects are computed for a range of devaluation rates from a fixed exchange rate (0% devaluation rate) to a devaluation rate of 100%.