Transfer problem dynamics: Macroeconomics of the Franco-Prussian War indemnity*

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Abstract

We study the classic transfer problem using the largest historical example, the Franco-Prussian War indemnity of 1871-1873 which saw France transfer to Germany 25 percent of a year's GDP. A dynamic, two-country model allows for debt finance, supply-side effects, and controls for wartime spending. The model can fit the historical paths of French net exports and the terms of trade. But explaining French output and consumption requires additional shocks. These results illustrate the usefulness of the DSGE approach to the transfer problem and provide striking evidence of the importance of international capital markets in the nineteenth century.

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1. Introduction

What are the economic effects of a unilateral transfer of resources between countries? In textbooks on international economics, this question is referred to as the 'transfer problem'. Transfers were an endemic feature of economic history (at least until the 1930s); they typically followed wars, and were imposed by the victors on the defeated party. Although the debate on the transfer problem goes back to the 19th century, the best known reference is the Keynes-Ohlin controversy in the 1929 *Economic Journal* concerning the impact of German reparation payments after the 1914-18 War.

Despite the empirical prevalence of transfers, most of the literature on the transfer problem has been theoretical, and set in the context of static models of international trade. Many studies focus on quite narrow questions regarding the impact of the transfer on welfare of the donor or the recipient. Since the traditional models tend to ignore many critical channels through which transfers may operate, such as endogenous output, capital accumulation, and international capital markets, they do not easily allow for a quantitative investigation of transfers.

This paper studies the transfer problem using a multi-country growth model. Within this framework, transfers can have a rich series of effects, depending on the sectoral structure of the economy, the assumptions about labor supply and investment technology, and the degree of access to international capital markets. Our principal focus is on the quantitative impact of a transfer. Transfers represent large shifts in wealth between countries within a short time period. They thus represent experiments that can be used to test models of international economics. In this study, we focus on the largest transfer in history; the Franco-Prussian War indemnity payment of 1871-73.

There are a number of reasons why the study of large transfers is of interest. First, understanding the response to a transfer can shed light on the way to build models in open-economy macroeconomics. For example, the response of the current account to the transfer may help us assess the intertemporal approach to the current account or the related question of how to model market incompleteness or limits on international risk-sharing. Similarly, the response of prices to the transfer should be informative about general equilibrium models of the terms of trade.[1]

Second, as we have noted, transfers play an important role in economic history. The Franco-Prussian War indemnity was blamed by popular historians for everything from the

[1] A standard reference on the intertemporal approach to the current account is Obstfeld and Rogoff (1995). See Backus, Kehoe and Kydland (1994a,b) for modelling terms of trade movements.

German stock market crash of 1873 to slow population growth in France. Since transfers generally followed wars, identifying the economic effects of the transfer or reparations requires that we control for other shocks, such as those to government spending during wartime.

Although much has been written about the transfer problem in general, and the Franco-Prussian war indemnity payment in particular, to the best of our knowledge, there have been no quantitative, historical studies of the macroeconomic effects of transfers that use a DSGE method. Our quantitative investigation of the effects of the transfer employs a conventional, two sector, dynamic, general equilibrium model of open economies, in which we look at a transfer in combination with other shocks. Using data from France during the 1860s and 1870s, we describe the historical evolution of the key macroeconomic aggregates, including GDP, net exports, and the terms of trade. We then measure the scale of the transfer and separately measure a shock to fiscal policy, because the transfer took place immediately after a wartime spike in government spending. The historical shocks are used as inputs in the model, producing sample paths for the relevant time series. Our approach is then to compare these model-determined sample paths with the historical series.

The model is very successful in matching the historical sample paths of the trade balance and the terms of trade in France. We describe in detail the series of macroeconomic responses within the model which accounts for this match. We also find that the shock to fiscal policy, a traditional candidate for explaining changes in the current account, has little effect. Its role is modest because of the small size of the nineteenth-century government sector and possibly because of a simultaneous shock in Germany.

We conclude that some third shock is needed to explain the paths of French output and consumption. No direct measurements of supply-side shocks are available. But simulations of productivity shocks show that they potentially can reproduce the historical changes in output and consumption without disrupting the model's successful predictions for the trade balance and terms of trade. The transfer's minor impact on consumption is striking evidence of the openness of international capital markets.

Section 2 gives background and sources for previous research on the transfer problem. Section 3 explains why we adopt the Franco-Prussian War indemnity for study, and gives some associated history. Section 4 develops a static, two-country model of the effects of the transfer on the terms of trade. This setup introduces much of the notation and is in keeping with most of the theoretical work on the transfer problem. Next, section 5 introduces debt and capital. Section 6 contains numerical results from the dynamic model, and compares its sample paths to those from history. Section 7 contains a discussion of other shocks. Section 8 concludes.

2. Research on the Transfer Problem

J.S. Mill (1844) predicted that a transfer-paying country would experience a deterioration in its terms of trade, thus adding to the burden of the transfer. Keynes (1929) elaborated, arguing that the donor government's increase in supply through the non-market transfer drives down the price of its exports. Ohlin (1929) called this the 'orthodox' view and argued that it might not hold because of income effects. The recipient is richer as a result of the transfer and so spends more on the donor's goods. The donor is poorer and so spends less on the recipient's goods. Thus the donor's terms of trade may improve. But Samuelson (1952) showed conditions under which the orthodox view was correct. In a competitive, two-good, two-country world the donor's terms of trade deteriorate iff its marginal propensity to consume its export good is greater than that of the recipient.

The large literature on the transfer problem, completely reviewed by Chipman (1974) and Brakman and van Marrewijk (1998), is generally static and theoretical. It is concerned with factors such as distortions, third parties, public goods, or tied aid. In this research, intertemporal trade generally is ruled out. But historical transfers often were financed through borrowing, rather than paid from current national income. Several papers have examined some implications of international borrowing. Brock (1996) studied transfer problem dynamics and allowed for borrowing. He considered a small open economy with fixed terms of trade, and so focused on the adjustment of the relative price of non-traded goods. Obstfeld and Rogoff (1996) discussed the transfer problem in a model of transport costs and non-traded goods, and argued that this framework supports Keynes's view of the effects of a transfer. Obstfeld and Rogoff (1995) emphasized a different mechanism, coming from the wealth-induced expansion in labor supply resulting from a transfer, which leads to a terms of trade deterioration for the donor. Both of these latter mechanisms are incorporated in our dynamic model below.

The original commentators on the transfer problem, such as Rueff (1929), emphasized the role of the terms of trade, so we adopt a two-country model and make that endogenous. Ritschl (1998) used Keynesian import equations to empirically study the effects of credit constraints implied by the Young Plan on Germany after 1929. White (2001) studied the reparations paid by France after the Napoleonic Wars from the perspective of the intertemporal approach to the current account. He concluded that consumption was smoothed through international borrowing, but not by as much as predicted by theory. He also used a neoclassical growth model to estimate the costs of various ways of financing that transfer.

As mentioned in the introduction, empirical work on the transfer problem is rare. But two studies have estimated some of the effects of the Franco-Prussian War indemnity.

Lévy-Leboyer and Bourguignon (1990, pp 243-247) studied the effects of both the war and the indemnity by adjusting and simulating an estimated, econometric model. Gavin (1992) suggested that consumption smoothing (the intertemporal approach to the current account) was relevant, but did not formally apply that approach. He used trends to gauge the effects of the transfer on French and German saving and investment during the 1870s.

3. The Franco-Prussian War Indemnity

This transfer is an ideal candidate for study. It was virtually a lump sum, was of a large scale, was successfully made, and was largely free of default risk. The transfer took place in an environment of relatively free international capital markets. Data on the terms of trade and on macroeconomic aggregates are available for France and some of its trading partners for this period.

After the Franco-Prussian War, France owed Germany an indemnity of 5 billion francs. Under the Treaty of Frankfurt, France agreed to pay this amount by 1 March 1875. Devereux and Smith (2005, appendix A) translate the relevant article of the treaty. In fact, most of the money was raised through two domestic bond issues in 1871 and 1872, which were heavily over-subscribed. Payment was complete during 1873. As Kindleberger (1993, p 245) noted:

> Particularly noteworthy in the light of the subsequent transfer problem with German reparations after World War I was that with no Keynes to tell them that transfer was impossible, the recycling and subsequent real transfer took place without any banker, economist, or government official giving thought to the question of whether the transfer was feasible.

The transfer consisted of bills of exchange and to a lesser extent gold, silver, and bank notes. The purchase of these bills was financed by the issue of callable perpetuities. Many of these bonds were purchased by foreigners, and many French foreign asset holdings also were sold. Monroe (1919) gave a detailed description of the timing, source, and composition of payments.

France's GDP in the early 1870s was just over 20 billion francs, so the three-year, total transfer in present-value terms constituted roughly 25 percent of a year's GDP or to two and a half times the annual government budget in France. This payment was the largest transfer in history. Brakman and van Marrewijk (1998, table 1.7) measure transfers using the ratio of the average annual payment to GNP. By that measure the indemnity payments averaged 8.67 percent of GNP each year from 1871 to 1873. In contrast, the German reparations payments of 1929-1932 averaged 2.5 percent of GNP, the Finnish transfers to the USSR in 1944-1948 averaged 4 percent of GNP, and the transfers from the former West to East Germany in 1991-1995 averaged 4.25 percent of GNP. The Franco-Prussian

indemnity was also large as a share of the recipient's GDP, for in 1870 Prussian/German GDP was only slightly greater than that of France.

The only comparable transfer was again made by France, but in 1815 after the Napoleonic Wars. White (2001, table 5) shows that these reparations were 18-21 percent of GDP but constituted a larger share of exports than did the indemnity of 1871. They also were a very large burden because they took place at a time of high real interest rates. We do not study this transfer because it took place over a longer time period (1815-1819) and because measures of the terms of trade and consistent national accounts are not available for that period.

Aside from the scale and pace of the transfer, the 1871 indemnity is notable also because there was virtually no sovereign debt risk associated with it. The timetable for the withdrawal of Prussian troops from French territory was explicitly linked to indemnity payments. Adolphe Thiers, the president of the republic from 1871 to 1873, was committed to early payment of the indemnity and was acceptable to Bismarck partly for that reason.

Most of the economic history on the indemnity has to do with the financial aspects rather than the macroeconomic effects. For example, Say (1898), Kindleberger (1993), and Landes (1982) discussed the financial arrangements for the transfer. But some historians have debated the economic costs to France of the indemnity and whether the German boom of the early 1870s can be attributed to the transfer. Eagly (1967) described the widespread view that the post-1873 depression was more severe in Germany than in France *and* that this difference was caused by the indemnity. He called this the 'potlatch' theory. In France, a rumour circulated that Germany was considering returning the indemnity.

Monroe (1919) presented some data which suggested that the German recession after 1873 was relatively severe. Norman Angell's 1913 best-seller, *The Great Illusion*, argued for the futility of reparations and of the Franco-Prussian War indemnity in particular. More thorough research on Germany has shown that its recession probably was no more severe than those in other countries. O'Farrell (1913) argued that the mid-1870s business cycle was worldwide. Eagly gave data on output in several sectors (coal, iron) and showed that in real terms the German recession was in fact slightly milder than the French one. Even the stock market boom in Germany may have been due to an easing of incorporation laws, rather than to the indemnity. Unfortunately, German macroeconomic data for the 1870s remain incomplete. While these works have debated the macroeconomic data for Germany, they have not been concerned with formally modeling the effects of the transfer.

The historical record for France can best be seen through some time series graphs. The solid line in Figure 1 shows France's annual current account balance as a share of GDP.

Consistent data are available thanks to the achievement of Lévy-Leboyer and Bourguignon (1990); details are given in our appendix. In the years before the transfer, France ran a current account surplus, averaging roughly 5 percent of GDP.

Next, we use the indemnity payments estimated by Lévy-Leboyer (1977): 1.435 billion F in 1871, 1.801 billion F in 1872 and 2.295 billion F in 1873, or 7.24%, 8.68%, and 11.1% of GDP. Adding these to the the current account balance shows the balance net of the indemnity. As a share of GDP, this net figure is shown in the dotted line in Figure 1. Clearly the indemnity was greater than the other components of the current account during those years, so a significant part of it was financed by selling assets or by borrowing internationally. This borrowing to finance a lump-sum loss of national wealth and to smooth consumption seems consistent with the intertemporal approach to the current account. Of course, to formally test a model of the current account requires that we model other shocks as well. Pertinent to this, both saving and investment, as shares of GDP, fell sharply from 1870 to 1871, but savings recovered more rapidly, as is also reflected in the current account series in figure 1.

Much of the theoretical work on the transfer problem has focused on the effect of a transfer on the terms of trade of the donor and of the recipient. The terms of trade is defined as the ratio of import prices to export prices: $s \equiv p_m/p_x$. Figure 2 shows the French terms of trade (solid line) and the trade balance as a share of GDP (dashed line). The figure shows that the French terms of trade deteriorated during the early 1870s, as predicted by standard models of international transfers (and, for the 1920s, by Keynes).

The theory applies to per capita measures, and so we deflate quantities using Mitchell's (1998) mid-year population estimates. In many applications, this transformation would not matter, for French population stagnated during this period, growing by only 0.36% per year from 1861 to 1866 and by 0.54% per year from 1872 to 1876. In this case, though, we need to adjust for the loss of Alsace and Lorraine in 1871, as the Mitchell data do. Those regions comprised roughly 4% of French population.

We constructed series for real, per capita output, consumption, and government spending for France. These series are measured by dividing the nominal series by the cost of living and the population series. Output and consumption both dropped sharply during the war, then recovered even as the indemnity was being paid. Output was disrupted by the occupation and loss of Alsace-Lorraine, by the siege of Paris, by the Paris Commune, and by the political uncertainty associated with the founding of the Third Republic. We next explore what economic theory predicts about the transfer's contribution to the changes in these variables.

4. Preferences, Goods, and an Exchange-Economy Example

To estimate the quantitative effects of the transfer, we begin with a static, exchange-economy model. Most existing models of the transfer problem are static. This exercise sets a standard of comparison, so that we can later show the effects of current account dynamics and endogenous production. In addition, the static model introduces much of the notation used in the paper.

Two regions are denoted home (France) and foreign (the world minus France but including Germany). The foreign economy is the rest of the world because France could finance the transfer by borrowing from third countries and because its net exports and terms of trade data are relative to the rest of the world rather than with Germany. Foreign variables are labelled with an asterisk. We normalize so that the world population is unity. Then we let the French population constitute a proportion ω of the world economy. Each agent has an endowment of a country-specific good: x in France and m abroad. Consumption of a good in France is denoted c_i, $i \in \{x, m\}$. France imports c_m and exports c_x^*.

Market clearing in the two traded goods implies that domestic consumption and foreign purchases exhaust output each period:

$$\begin{aligned} x &= c_x + \left(\frac{1-\omega}{\omega}\right) c_x^* \\ m &= \left(\frac{\omega}{1-\omega}\right) c_m + c_m^*. \end{aligned} \tag{1}$$

Let s be the French terms of trade, expressed as the ratio of import prices to export prices. Without lending and borrowing, trade must balance each period, including a transfer T:

$$\left(\frac{1-\omega}{\omega}\right) c_x^* = s\, c_m + T. \tag{2}$$

An increase in the transfer requires an equal increase in the French trade surplus.

French consumers consume an aggregate c composed of domestic goods and imports. This aggregate is given by:

$$c(c_x, c_m) = \left[\mu^{\frac{1}{\lambda}} \omega^{\frac{1}{\lambda}} c_x^{1-1/\lambda} + (1-\omega)^{\frac{1}{\lambda}} c_m^{1-1/\lambda}\right]^{\frac{\lambda}{\lambda-1}}, \tag{3}$$

so that λ is the elasticity of substitution and $\mu > 1$ indicates a preference for home goods. The population weight ω enters this definition because country size determines the share of a country's consumption that comes from home goods. Foreign consumption is of the same form.

In France, utility maximization yields:

$$\mu^{\frac{1}{\lambda}}\left(\frac{\omega}{1-\omega}\right)^{\frac{1}{\lambda}}\left(\frac{c_x}{c_m}\right)^{-\frac{1}{\lambda}}=\frac{1}{s} \tag{4}$$

and in the rest of the world:

$$\mu^{\frac{1}{\lambda}}\left(\frac{\omega}{1-\omega}\right)^{-\frac{1}{\lambda}}\left(\frac{c_m^*}{c_x^*}\right)^{-\frac{1}{\lambda}}=s. \tag{5}$$

Given endowments x and m and a transfer T, equations (1), (2), (4) and (5) determine consumptions c_x, c_m, c_x^*, c_m^*, and the terms of trade s. As an example, suppose there is no preference for home goods, so that $\mu = 1$. Then $s = (x/m)^{\frac{1}{\lambda}}$. As in Backus, Kehoe, and Kydland (1994b) for example, the terms of trade depend only on the endowment ratio. There is no transfer effect on the terms of trade.

Any preference for home goods ($\mu > 1$) implies that a transfer leads to a deterioration of the French terms of trade (a rise in s). The rest of the world consumes more of its own export good, good m, with the transfer than France would have done, so the relative price of foreign goods rises and the French terms of trade deteriorate. For non-Cobb-Douglas preferences there is no analytic solution. Brakman and van Marrewijk (1998, chapter 3) provide a proof that home bias leads to a deterioration in the donor's terms of trade and a lucid discussion of the general static model. Note that country size in itself does not matter for the level of the terms of trade, because a rise in ω increases both the relative supply of French goods and the relative weight of French consumers.

Before describing the model's quantitative predictions, we also allow for non-traded goods. These were clearly important in France and its trading partners during the 1870s. For example, agriculture, services, transport, and government made up almost two-thirds of French GDP in 1870. While agriculture includes goods such as silk and wine that were traded internationally, these sectors also include a large non-traded component. Moreover, in the more general model of the next section, labor mobility between non-traded and traded goods sectors will have an important role in the response to the transfer.

Non-traded goods also played a role in the original Keynes-Ohlin debate on the terms of trade. Ohlin (1929) argued that the presence of non-traded goods – and the possibility of changes in the internal terms of trade – influences the required changes in the international terms of trade. But Chipman (1974) proved that the orthodox view continues to hold if each country specializes in the production of its exportable good and a nontraded good.

Now suppose France has an endowment n of non-traded goods, while the foreign economy has an endowment n^*. French consumption is an aggregate of traded goods c_T and non-traded goods c_N:

$$c = \left[\gamma^{\frac{1}{\theta}} c_T^{1-\frac{1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} c_N^{1-\frac{1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{6}$$

where the consumption of traded goods remains a composite of French and foreign traded goods as written in equation (3).

The consumer price index is:

$$p = \left[\gamma p_T^{1-\theta} + (1-\gamma) p_N^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{7}$$

The consumption-based price index of traded goods is:

$$p_T = \left[\mu\omega + (1-\omega) s^{1-\lambda}\right]^{\frac{1}{1-\lambda}}, \tag{8}$$

where s is the terms of trade. The French budget constraint now is:

$$pc = x + p_N n - T, \tag{9}$$

where the transfer T is measured in traded goods and p_x is normalized to one.

Now the internal terms of trade, the relative price of traded to non-traded goods, is given by:

$$\left(\frac{\gamma}{1-\gamma}\right)^{\frac{1}{\theta}} \left(\frac{c_T}{c_N}\right)^{-\frac{1}{\theta}} = \frac{p_T}{p_N}. \tag{10}$$

The non-traded good is given by an endowment n, so that $n = c_N$. Market-clearing conditions for traded goods (1) continue to apply.

Similar conditions apply in the starred, rest of the world except that their preference over goods x and m is the reverse of that of the French. Then the model's equations can be solved for the nine unknowns: s, p_N, p_N^*, c_N, c_N^*, c_x, c_x^*, c_m, and c_m^*, and the consumption of individual goods may be aggregated to give aggregate consumption.

Consider a numerical example with parameters set as follows. France's share of world GDP is $\omega = 0.165$ (based on France's share of GDP in the developed world in 1870, estimated from Maddison 1991, tables 1.1 and B.1). The ratio of exports to GDP for France in 1870 was 15 percent. Given the other parameter settings, the value of μ which reproduces this ratio is 6.5. The elasticity of substitution between traded exports and imports is $\lambda = 1.5$. This is the same number used by Backus, Kehoe, and Kydland

(1994a).[2] The elasticity of substitution between traded and non-traded goods is set at $\theta = 0.75$. Allowing for some traded component of the agriculture sector, we use an estimate of the non-traded goods sector at 50 percent of GDP, so we set $\gamma = 0.5$.

Table 1 gives some results from the static model, and compares them with evidence for France. The table shows the model's predictions for the changes in the terms of trade and consumption. We conduct three exercises. First, we impose a transfer of 7.2 percent of GDP, the actual transfer paid in 1871 as a proportion of GDP. Alternatively, we look at the payment of the full transfer, equal to 25 percent of GDP. Finally, to offer a realistic comparison with the dynamic model, which allows borrowing, we study the impact of a transfer equal to rT, or the annuity value of the full transfer, where r represents the real interest rate used to construct the annuity (we assume $r = 0.05$). The logic of this final experiment is that even in the absence of explicit international capital markets, the transfer from the donor to the recipient country may be affected by a permanent flow payment equal to the annuitized value of the full transfer.

The model's predictions can be compared to the evidence for France in the lower rows of table 1, for the data represent the terms of trade with the rest of the world, rather than with Germany. The transfer began in the middle of 1871, so we present changes beginning in 1870 and alternately in 1871. The first two exercises predict greater deterioration in the terms of trade than the historical record. The third exercise (the annuitized transfer), predicts too small a deterioration in the terms of trade. The movement in consumption is also relatively poorly predicted by this model. For the full immediate transfer, consumption falls by much more than the historical fall. For the annuitized transfer, consumption falls hardly at all, while for the 7.2 percent transfer, the consumption fall is in the region of the 1870-71 consumption decline. While the actual path for consumption fell from 1870 to 1871, it then grew in subsequent years.

Two features obviously are missing from the model. First, in the static model there is no ability to respond to the transfer by borrowing or by adjustment in output, either by investment, movements in total labor supply, or shifts in employment between the non-traded and the traded goods sectors. Second, the model is missing other shocks. Figure 2 shows large movements in the French terms of trade during other years, when transfers did not occur. We need to identify other shocks to explain those fluctuations, and so must control for those shocks to try to isolate the effects of the transfer.

[2] There is some debate about the value of this elasticity. Ruhl (2003) argues that the aggregate, measured elasticity in response to permanent changes in relative prices may be much higher than this value, due to endogenous entry into the export sector. But at business-cycle frequencies, as in our study, he estimates an elasticity of 1.4.

5. International Debt and Capital Dynamics

In this section we extend the model to allow for international debt, physical capital accumulation, variable labor supply, and labor mobility across sectors. Let household preferences be given by:

$$U = \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} + \eta \frac{(1-h_t)^{1-\nu}}{1-\nu} \right), \tag{11}$$

with $\sigma,\ \nu > 0$ and as before $c = c(c_T, c_N) = c(c_x, c_m, c_N)$. The discount factor, β, is common across countries. Households consume a composite goods bundle and supply labor, h_t.

Bonds are the only internationally traded asset. Therefore households in France cannot diversify away the income effects of a transfer. The higher French tax burden caused by the transfer must be fully met by French tax-payers. This asset-market incompleteness gives rise to real effects from the transfer, and also is realistic given the well-known home bias in investment portfolios.

As in section 4, the domestic export good is the numeraire, so $p_{xt} \equiv 1$. International bonds are denominated in domestic exports. The consumer purchases the composite consumption good, c_t, and invests in capital in the export sector and in the non-traded sector. The return on international bonds, r_t, is denominated in domestic exports. Taxes collected by the government are given by τ_t. The budget constraint for French households thus is:

$$p_t c_t + b_{t+1} + p_t i_{xt} + p_t i_{Nt} = w_t h_t + r_{xt} k_{xt} + r_{Nt} k_{Nt} + (1 + r_t) b_t - p_t \tau_t. \tag{12}$$

Capital accumulates according to:

$$k_{xt+1} = \phi\left(\frac{i_{xt}}{k_{xt}} \right) k_{xt} + (1-\delta) k_{xt}, \tag{13}$$

and

$$k_{Nt+1} = \phi\left(\frac{i_{Nt}}{k_{Nt}} \right) k_{Nt} + (1-\delta) k_{Nt}. \tag{14}$$

In this technology, $\phi' > 0$, $\phi'' < 0$, and $\phi(\delta) = \delta$. This captures adjustment costs of capital that prevent capital moving between sectors and across borders with unrealistic speed.

In an optimal consumption plan, traded goods consumption is divided among domestic and foreign goods as:

$$c_{xt} = \mu\omega \left(\frac{1}{p_{Tt}} \right)^{-\lambda} c_{Tt}, \tag{15}$$

and

$$c_{mt} = (1-\omega)\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda} c_{Tt}. \tag{16}$$

Total consumption is divided among traded and non-traded goods as:

$$c_{Tt} = \gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta} c_t, \tag{17}$$

and

$$c_{Nt} = (1-\gamma)\left(\frac{p_{Nt}}{p_t}\right)^{-\theta} c_t. \tag{18}$$

Saving decisions stem from the usual Euler equations:

$$\beta \mathrm{E}_t\left[\frac{p_t c_t^{\sigma}(1+r_{t+1})}{p_{t+1}c_{t+1}^{\sigma}}\right] = 1. \tag{19}$$

Hours worked are chosen to satisfy:

$$\eta(1-h_t)^{-\nu} = c_t^{\sigma}\frac{w_t}{p_t}. \tag{20}$$

Capital in the export sector is chosen according to:

$$q_{xt}c_t^{-\sigma} = \mathrm{E}_t\beta c_{t+1}^{-\sigma}\big[\frac{r_{xt+1}}{p_{t+1}} + (1-\delta)q_{xt+1}\big], \tag{21}$$

where $q_{xt} = 1/\phi'(i_{xt}/k_{xt})$ is the real price of a unit of capital in the export sector, in terms of the composite good, and r_{xt+1} is the rental rate on capital in the export sector. A similar relationship holds in the non-traded sector, with relative price q_{Nt}.

Firms face a static optimization problem, and simply maximize profits. Production functions are Cobb-Douglas, with capital share α in the export sector and κ in the non-traded sector. The profit-maximizing conditions for the two sectors are:

$$\begin{aligned} r_{xt} &= \alpha k_{xt}^{\alpha-1}h_{xt}^{1-\alpha} \\ w_t &= (1-\alpha)k_{xt}^{\alpha}h_{xt}^{-\alpha} \\ r_{Nt} &= p_{Nt}\kappa k_{Nt}^{\kappa-1}h_{Nt}^{1-\kappa} \\ w_t &= p_{Nt}(1-\kappa)k_{Nt}^{\alpha}h_{Nt}^{-\kappa}. \end{aligned} \tag{22}$$

For simplicity, we assume that the government finances a transfer and government spending with a lump-sum tax. Its budget constraint is:

$$p_t g_t + T_t = p_t \tau_t. \tag{23}$$

The implicit assumption here is that government spending falls across sectors in the same proportion as private spending. We cannot test this assumption directly, but Fontvielle (1976, table xv) showed that a large part of the wartime increase in public expenditure could be attributed to salaries.

Following recent, numerical methods in open economy macroeconomics, developed by Kollmann (2002) and Schmitt-Grohé and Uribe (2003), we assume that there is a debt-elastic differential between the home and foreign rates of interest. Thus, denoting the foreign rate of return (in terms of good x) as r_t^*, and French net foreign assets by b_t, the relationship between French and world interest rates is given by

$$(1 + r_{t+1}) = (1 + r_{t+1}^*)\psi(b_{t+1} - \bar{b}) \tag{24}$$

where the function $\psi(b_{t+1} - \bar{b})$ satisfies $\psi(0) = 1$, and $\psi' < 0$. This function captures the idea of an upward-sloping supply curve of foreign credit. When the economy is a net borrower, it faces an interest rate that is higher than the interest rate of its trading partner. When it is a lender, it receives an interest rate that is lower than that of the other country. This specification plays two roles. First, from a technical viewpoint, it eliminates the presence of a unit root in the world wealth distribution, because $\bar{b}$ represents a steady-state level of net foreign assets for the home country. Second, it captures the presence of 'frictions' in the international capital markets. As these frictions become larger and larger, captured by a larger absolute value of ψ', the effect of the transfer is more and more contained within the period of the transfer, and the use of international capital markets to smooth out the impact of the transfer is reduced. As Schmitt-Grohé and Uribe (2003) show, this friction has an effect on the response of an open economy that is essentially identical to a number of alternative methods for dealing with a unit root in the wealth distribution, such as assuming endogenous time preference or adjustment costs of international bond purchases. Empirically, Lane and Milesi-Ferretti (2001) have estimated a negative relationship between real interest rate differentials and net foreign assets for a panel of industrial and developing economies between 1971-1998.

In each country, labor can be allocated to the non-traded sector or to the traded sector:

$$\begin{aligned} h_t &= h_{xt} + h_{Nt} \\ h_t^* &= h_{mt}^* + h_{Nt}^*. \end{aligned} \tag{25}$$

The non-traded goods market clears in each country:

$$\begin{aligned} k_{Nt}^{\kappa} h_{Nt}^{1-\kappa} &= (1-\gamma)\left(\frac{p_{Nt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ k_{Nt}^{*\kappa} h_{Nt}^{*1-\kappa} &= (1-\gamma)\left(\frac{p_{*Nt}}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*). \end{aligned} \tag{26}$$

Markets for each traded good clear:

$$
\begin{aligned}
k_{xt}^{\alpha} h_{xt}^{1-\alpha} &= \mu\omega\left(\frac{1}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\
&\quad + (1-\omega)\left(\frac{1}{p_{Tt}^*}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}^*}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*) \\
k_{mt}^{*\alpha} h_{mt}^{*1-\alpha} &= \omega\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\
&\quad + \mu(1-\omega)\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}^*}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*).
\end{aligned}
\tag{27}
$$

An equilibrium determines the time path of interest rates, relative prices of non-traded goods, the terms of trade, and wages, as well as the consumption, capital, and employment for each country, and net foreign assets.[3] Section 6 next studies the effects of the transfer on France in this dynamic economy.

6. Effects of the Transfer

In the dynamic model, there are additional parameter values that need to be determined. Table 2 describes the calibration. For many of the parameter values, we have no sources pertaining to France, Germany, and the other industrial countries in the 1870s, so we simply follow the common parameter assumptions of the international macroeconomics literature. For instance, we assume that the labor share of output in each sector is 0.64, and that the common rate of depreciation of physical capital is 10 percent in each sector. We assume that the elasticity of intertemporal substitution in consumption is 1 (so that $\sigma = 1$) and that $\beta = 0.94$ so that the steady-state real interest rate is 6 percent. There is a range of estimates for the elasticity of substitution between export and import goods. We follow Backus, Kehoe, and Kydland (1994a) in setting $\lambda = 1.5$. Estimates of the elasticity of substitution between non-traded and traded goods, θ, also vary considerably. We follow Burstein, Neves, and Rebelo (2003), who use a value of θ equal to unity. Our results generally are not sensitive to variations in this elasticity. The parameter $\gamma = 0.5$ determines the observed share of expenditure falling on non-traded goods in the French economy. As before, $\mu = 6.5$ replicates the export/GDP ratio for France. We calibrate capital adjustment costs so that the elasticity of Tobin's q in each sector with respect to

[3] In principle, the small implicit costs associated with capital market frictions described in equation (25) should come from domestic or foreign resources. But since we take a linear approximation around a steady state with $r{=}r^*$, these costs do not appear in the solution, so we ignore them in the description of the model.

the investment-capital ratio is 0.3, following recent literature (*e.g.* Bernanke, Gertler, and Gilchrist, 2000).

We estimate that French net foreign assets were 60 percent of GDP in 1870. Thus, for the function $\psi(b_{t+1} - \bar{b})$, we calibrate so that in a steady state, $\bar{b}$ is 60 percent of steady-state GDP. Then we may approximate (24) as

$$r_t = r_t^* - \chi b_t. \tag{28}$$

Estimates of the parameter of the 'risk-premium', χ, vary. Lane and Milesi-Ferretti's estimates suggest a value of $\chi = .001$. Using a different approach, Schmitt-Grohé and Uribe's (2003) estimates translate into $\chi = .01$. The discussion paper predecessor to this article (Devereux and Smith, 2005) describes our own estimates of χ using French net foreign assets and the French-British interest-rate differential. But these were unstable.

Given the instability from this additional source of information, we use the value $\chi = 0.01$, a value used in some recent studies of twentieth-century data. One can think of our approach then as asking whether a model with minimal, late-twentieth-century frictions in the capital market can fit these nineteenth-century data. However, we also varied the value of χ and studied the fit of the model. The results show that the model with $\chi = 0.01$ fits French data quite well, so this sensitivity exercise can be thought of as an informal econometric estimator. But of course matching sample paths can still serve as a test of the model. In other words, we cannot rig the results by judicious choice of χ. There is ample overidentification as we compare the model and historical data for several variables and for multiple years.

The model is solved by linear approximation around an initial steady state. Linear approximation in principle may be inappropriate given a transfer of this magnitude, but previous research has established that dynamic, constant-returns-to-scale economies of this type are quite 'smooth', so that the true dynamic solution behaves in an approximately linear fashion.

We now focus on the impact of an unanticipated transfer from France to Germany. We introduce this shock in the model as follows, using the numbers described in section 3. In 1871, a previously unanticipated transfer of 7.24 percent of GDP is made, but agents then forecast accurately the payments of 8.68 and 11.1 percent of GDP for the succeeding two years. Since the full size of the indemnity payment was negotiated in 1871, clearly agents were able to forecast the occurrence of future payments. While the time path of payments may not have been fully predicted in 1871, in the presence of international capital markets,

the time path of payments is approximately irrelevant (and exactly irrelevant when $\chi = 0$).[4]

The solid lines in Figure 3 illustrate the impact of the transfer in the baseline model. The figure shows the impulse response pattern for GDP, the terms of trade, the trade balance-GDP ratio, and consumption. The responses for GDP, the terms of trade, and consumption are measured in percentage points, while the response for the trade balance-GDP ratio is in levels.

Figure 3 indicates that the the trade balance improves by about 3 percent of GDP. Since this falls short of the transfer made in 1871, the current account balance, including the transfer, must fall, as the economy goes into debt to finance the transfer. The improvement of the trade balance is generated by a fall in domestic consumption and a rise in domestic output. Overall output can rise because the fall in consumption increases French labor supply. In addition, however, inter-sectoral labor mobility is important here, as labor moves from the non-traded sector into the traded goods sector. The effect of the transfer on investment (not shown in figure 3) is more complex. Investment in the non-traded sector falls, because the fall in domestic consumption reduces non-traded output. But investment in the export sector increases, because the increase in employment increases the return to capital in this sector. The first of these effects tends to dominate, and investment falls by a small amount.

The full impact of the transfer on the terms of trade in the dynamic economy is attributable to a combination of shifts in world demand from French to German and other foreign consumers, and to an expansion in the relative supply of French to rest-of-world exportable goods. To give some insight into the factors involved, we investigate some departures from the baseline calibration. First, we eliminate home bias in preferences, setting $\mu = 1$. This case is shown in the dotted lines in figure 3. This leads to a significantly lower response of the terms of trade – a 3 percent deterioration, compared to 6 percent in the baseline model. This deterioration arises because the increase in labor supply leads to an expansion in French export output, and a fall in its relative price.[5] Note however that

[4] Some transfer may have been expected during 1870 as the outcome of the war became clear, for Prussia had demanded indemnities from Austria and several south German states during the 1860s. Contemporary sources described the scale of the actual indemnity demanded in 1871 as many times greater than expected, though, so we treat the transfer as a surprise.

[5] With endogenous production, the classic implication of a transfer, that it reduces the donor's terms of trade, does not hinge on home-good bias in preferences. This point has also been noted by Obtsfeld and Rogoff (1995).

the absence of home bias in preferences has almost no consequence for the paths of output and consumption following the transfer.

The short-dashed lines in Figure 3 represent the case with zero labor supply elasticity, holding all other parameters constant. The size of the terms of trade deterioration is now reduced from 6 percent to about 5.5 percent, since output now falls gradually as a slight investment decline reduces the capital stock over time. If in addition, we rule out labor mobility across sectors (the long-dashed lines), then we find the terms of trade deteriorates by significantly less; only 4 percent, since traded good output cannot now expand at the expense of non-traded output.

Finally, we also examine the effect of setting $\chi = 0$. This eliminates the frictions in international capital markets. The impact of the transfer should now be more comparable to the case of the annuitized transfer in the static model, where the country pays the transfer as an annuitized flow over an infinite time horizon. While our exercise does correspond to a full payment of the transfer over just three years, the ability to access international capital markets without cost allows the country to spread the absorption cost of the payment out over an infinite time horizon.[6] In this case, we see a much smaller, but far more persistent response of all variables, shown in the dot-dashed lines in figure 3. The terms of trade deterioration is approximately three percent, and the trade balance improves by only 1.5 percent. The rise in output and fall in consumption are about half as much as in the baseline model.

How does the effect of a transfer in the model accord with that seen in the historical data following the French indemnity payments? Figure 4 superimposes the baseline results from Figure 3 (with a change of scale, in the solid lines) on the historical sample data from France (shown in the dashed lines). The data for real GDP per capita, the terms of trade, and real consumption per capita are de-trended for the 1860-1880 period, and the data shown represent deviations from trend. The terms of trade may be stationary, in principle, but figure 2 shows that there was an upward trend in the terms of trade for France over this period. Our aim is not to explain this trend, but rather the deviations that may be attributable to the transfer. For the net export share, we de-mean the series for the 1860-1880 period.

Figure 4 establishes that the baseline model generates a deterioration in the terms of trade that resembles the cyclical movement in the French terms of trade after 1871

[6] There still remain some differences between this case and the static model. First, output is endogenous through labor supply and capital accumulation. Second, the world real interest rate is endogenous, because, while France has a small share in the world economy, it is not a pure small economy as in the static model. Of these two, the first factor is the more important quantitatively.

quite closely. Both in the data and the model, the terms of trade deteriorate by about 6 percent, although the maximum terms of trade deterioration occurs slightly earlier in the model than in the data. In the model, this terms of trade deterioration is very persistent, since it is associated with persistently lower consumption and persistently higher output in France, as the economy experiences a higher debt-to-GDP ratio after borrowing to finance the transfer. In the data, the terms of trade falls back to its mean level within 4 years.

The movement of net exports in the data also is captured quite accurately by the model. The net export ratio rises by about 3 percent. However, the timing is slightly non-synchronous. The model predicts an immediate increase in 1871, as the transfer takes effect. In the historical data, there is a dip in the net export share in 1871, but this is reversed in 1872, and there is a strong trade surplus for the next four years. In the next section, we see that the addition of a fiscal policy shock will eliminate this discrepancy. Again, due to consumption smoothing, the trade surplus in the model is more persistent than that observed historically.

In the model, the movements of consumption and output following the transfer are quite unlike the historical ones. In the historical sample, consumption and output are 11 and 10 percent respectively below their mean levels in 1871. In the model, the effect of the transfer is to reduce consumption by about 3 percent, and *raise* output by about 1.5 percent. Output rises due to the wealth-induced expansion in labor supply. The fall in consumption is muted by the presence of international capital markets.[7]

How would the alternative parameterizations of figure 3 affect the comparison in figure 4? Eliminating the home bias parameter would lead to a much smaller, and counterfactual, terms of trade deterioration. Eliminating the endogenous response of labor supply on the other hand would lead to a slightly smaller deterioration in the terms of trade, but would leave the movement of the trade balance essentially unchanged. Finally, eliminating the risk premium term significantly worsens the comparison for all variables, as consumption, the terms of trade, and the trade balance fall by less, and all variables are much more persistent than is apparent in the sample data. Thus, the adjustment to the transfer implied by a purely frictionless international capital market (or the annuitized transfer experiment in the static model) seems not to accord well with the historical experience.

While the transfer is reasonably successful in accounting for the terms of trade and the trade balance, the discrepancy between the model and historical sample with respect

[7] We also found that the transfer had little ability, on its own, to explain the path of investment - the fall in investment in 1870-71 was far greater than implied by the transfer. The transfer has a very minor effect on investment in the model.

to the path of output and consumption suggests that it is important to allow for other shocks. We discuss this in the next section.

7. Shocks

Like many transfers, the Franco-Prussian War indemnity did not take place in a placid macroeconomic era. During 1870 France experienced a sharp increase in government spending as its armies (first imperial, then republican) were mobilized. It also experienced the destruction of capital and the disruption of trade through the siege of Paris by the Prussian army, the occupation, the Commune in 1871, and the loss of Alsace and Lorraine. To isolate the effects of the transfer, we need to control for these shocks.

The work of economic historians allows us to rule out certain shocks. First, tariffs did not change significantly in either France or its main trading partners during the early 1870s. Smith (1980) and Verdier (1994) have analyzed the political basis for this stability of French commercial policy. France had liberalized trade with Great Britain after 1860 under the terms of the Cobden-Chevalier treaty. During the 1860s, France signed similar treaties with other countries, and Napoleon III issued decrees to abolish import duties on most primary products. And free trade continued after 1870 under the Third Republic. Similarly, protection was not a major tool for Bismarck until 1879.

Second, monetary policy also was not a source of shocks. During this period France suspended gold convertibility from August 1870 to December 1877, but in fact maintained a fixed exchange rate, with the franc rarely departing from its gold parity value. Thus, we do not model *differential* monetary policy as a source of dynamics.

However, further work may be needed on the *joint* monetary stance of France, Germany, Britain, and their trading partners in the mid-1870s. Flandreau (1996) carefully documented the steps by which Germany left the silver standard and France left bimetallism in favour of gold, as did the United States. This process led to correlated monetary changes across countries and worldwide deflation after 1872 as silver was demonetized. Although the indemnity payments were completed by September 1873, their macroeconomic effects may be entangled with the effects of this monetary regime change. We do not view the transfer as a *cause* of this change in monetary regime. Although Germany used some of the proceeds of the indemnity to acquire gold, France also demonetized silver while paying the transfer.

We also considered – but ruled out – shocks from the rest of the world, which would affect France through foreign GDP, prices, or interest rates. As a check on this possibility, we constructed an index of rest-of-world real GDP for 1860-1880. This measure yielded no

evidence of a world business cycle in the early 1870s that would reflect an omitted shock. Nor was there a significant fluctuation in British interest rates during this period.

7.1 Government Spending

A long tradition in open-economy macroeconomics investigates the role of government spending in driving changes in the current account. French government spending rose from 793 million francs in 1869 to 1445 million francs in 1870 and 1897 million francs in 1871 before falling back to 925 million francs in 1872. To include this shock to government spending in the model, we first linearly detrend real government spending per capita for 1860-1880, then construct percent deviations from trend, denoted $\{\tilde{g}_t\}$. Our first measure of the fiscal shock is simply this series. According to this measure, any deviation from the trend comes as a surprise, and does not lead to a forecast of future deviations from the trend.

Our second measure of the shock is constructed using a linear projection:

$$\tilde{g}_t = \bar{g} + \rho_g \tilde{g}_{t-1} + v_t. \tag{29}$$

The estimate of ρ_g is 0.32, though its standard error – with only twenty annual observations – is 0.22. The shocks now are measured as the series $\{\hat{v}_t\}$. By removing the component of $\tilde{g}_t$ that is predictable at time $t-1$ we allow for some forecasting by economic actors around the trend. The empirical persistence measure, $\hat{\rho}_g$, is known to the forward-looking actors in the model. According to this second measure, once a surprise $\hat{v}_t$ occurs, agents also revise their forecasts for $\tilde{g}_{t+1}$ and beyond.

In practice, the series $\{\tilde{g}_t\}$ has a single spike during 1870 and 1871, so the two series are quite similar. With the second measure, there is a smaller shock in 1871, because a relatively high value is expected given the rise in spending in 1870. With the second measure, there also is a larger negative shock in 1872, because this measure builds in some persistence to forecasts. But given the limited persistence in the actual $\{\tilde{g}_t\}$ series, these differences are not large and so the two measures lead to very similar effects in the model.

To illustrate the impact of government spending shocks in the model, we used the second measure of fiscal shocks. Output rises because of the effects of the wartime fiscal expansion on labor supply. The government spending shock directly crowds out consumption. Output is 1.4 percent above trend in 1871, and consumption is 1.25 percent below trend. The rapid fall in government spending after the war means that these movements in output and consumption are quite temporary. The direct expansion in demand for domestic goods leads to an improvement in the terms of trade. The ratio of net exports to GDP deteriorates in 1870 and 1871 but then recovers as government spending falls.

While the wartime increase in government spending was very large, the overall impact on the economy is quite small, because the initial size of government in the economy is less than 5 percent of GDP. Still, the results of including this shock are worth noting, because the gaps between the predictions of the model with the transfer shock alone and the historical data on the terms of trade and trade balance (shown in figure 4) also are quite small. It is interesting to see whether allowing for the fiscal shocks closes these gaps.

The dotted lines in figure 4 update the predictions to reflect the model with both transfer and fiscal shocks. Both the terms of trade and the trade balance are fitted even more accurately when the fiscal shocks are included. The strong improvement in the trade balance that was predicted to begin in 1871 is now delayed until 1872, as in the data, as the government spending increase of 1871 reduces the impact of the transfer on the trade balance. In addition, the terms of trade is now closer to the historical path, as the increase in government demand slightly reduces the extent of the initial deterioration in the terms of trade. Finally, government spending may partly help explain the greater fall in consumption than is implied by the transfer, but with respect to GDP, the impact of government spending increases the discrepancy between the model and the historical sample.[8]

We lack a full decomposition of government revenues and so have assumed lump-sum taxes. Partial revenue data catalogued by Mitchell (1998, table G) show that increases in excise and registration taxes accompanied the payment of the indemnity. Fontvielle (1976) provided annual public accounts – showing the budget deficit widening during the war and indemnity period – but no information on tax rates or changes in them. This prevents us from studying the effects of the financing plan, along the lines originated by Ohanian (1997) for the twentieth-century U.S.[9]

A final reason why fiscal shocks may not have had a large effect on the terms of trade is that government spending rose and then fell in Germany, just as in France. Our model is, appropriately, not one of a small, open economy. Although we do not include this

[8] We also performed simulations under the alternative specifications from section 6. In the presence of both shocks, we found that the response of the terms of trade was somewhat less accurate with a zero elasticity of labor supply. Shutting off inter-sectoral labor mobility or eliminating capital market frictions substantially reduces the fit to both the terms of trade and the trade balance. These results are omitted to save space, but are available upon request.

[9] We did however examine the case where fiscal shocks were fully financed by a wage income tax. The differences relative to figure 4 are minor, essentially because of the small share of government spending in GDP. Again, these are omitted due to space constraints.

German shock, it would partially offset the effects of the French fiscal shock on the terms of trade and net exports.

7.2 Productivity

While the combination of the transfer shock and the fiscal shock is quite successful in explaining the trade balance and the terms of trade, it does not closely explain the movements of output and consumption. A natural additional shock to consider would be one which directly affects output, and so would also affect consumption. We considered a productivity shock and sought data on factor markets which would allow us to back out a Solow residual series. Devereux and Smith (2005) give an example in which including this shock helps explain the movement of output and consumption in the historical sample, without affecting the model's ability to track the trade balance and terms of trade.

But there is not enough auxiliary data available to make this approach convincing as a measure of productivity fluctuations. Moreover, there are more endogenous variables than shocks, so there is no unique way to back out z from macroeconomic data. We considered treating the model as a filter, and estimating the most likely z-series. But we ruled out this approach too, because of the limited, annual data.

8. Conclusion

The transfer problem is of interest for several reasons. It has played a large role in the development of theoretical models in international economics. In economic history, a range of economic effects have been attributed to transfers, without much formal modelling. Transfers can be viewed as large-scale experiments with which to test models of the terms of trade. And models of transfers are needed to predict the effects of current transfers, such as development aid.

Our work has shown how the predicted effects of a transfer depend on (a) international borrowing and lending, (b) supply-side responses, and (c) the degree of home bias in preferences. These three characteristics could also be taken into account in assessing contemporary transfers. For example, the response of a recipient's terms of trade to a transfer made by a government or international organization or to the repatriation of labor income may depend on the openness of private capital markets.

Our results indicate that a dynamic, general equilibrium model of the current account and terms of trade, which combines the transfer with historical changes in government spending, does well in matching the the terms of trade and trade balance after the Franco-Prussian War. We also found that productivity or supply-side shocks potentially could explain the variation in output and consumption, without much altering the models predictions for the terms of trade and trade balance. These results hold even though (a) we

have sought to match sample paths, rather than the weaker criterion of matching moments, and (b) we have studied the nineteenth century using parameter values from the twentieth century, rather than selecting parameter values to improve the fit of these paths.

Given the great size of the transfer, one might expect its effects to be glaringly obvious in the macroeconomic data, to the point where one need not even try to measure other shocks. Popular history often made this assumption, and attributed large economic effects to the indemnity. On the contrary, we find that some other shocks – such as changes in aggregate productivity – clearly are needed in order to fit French and German macroeconomic history, especially with respect to the movements of output and consumption. This finding is striking evidence of the importance of international capital markets in the late nineteenth century.

Appendix: Data Sources and Definitions

France:

Annual data for France are from Lévy-Leboyer and Bourguignon (1990). The following table gives the precise definitions of the measures we use, with the corresponding source in their monograph:

Measure	*Table*	*Series*
nominal GDP	A-III	1
net exports	A-III	5+6-7
investment	A-III	4+8
consumption	A-III	2
government spending	A-III	3
net foreign income	A-I	8
import prices	A-VI	4
export prices	A-VI	5
cost of living	A-IV	13
real wage	A-IV	14

Annual estimates of French population are from Mitchell (1998, table A5). These coincide with the quinqennial censuses and also reflect the loss of Alsace and Lorraine. Net foreign assets are from Lévy-Leboyer (1977), tableaux X, page 120.

Rest of the World:

Rest-of-the-world real GDP is the sum of real GDP in 1990 Geary-Khamis dollars for Germany, Italy, the UK, and the US from Maddison (2003) tables 1b and 2b. For the US, data for the 1860s are rescaled measures from Johnston and Williamson (2004).

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Table 1: Evidence on the Static Model

Transfer (% GDP)	Terms of Trade (% change)	Real Consumption (% change)
	Model Predictions ($\omega = 0.165$ $\mu = 6.5$)	
7.2%	13.2%	-8.1%
25%	45.9%	-30.8%
1.25%	2.3%	-1.4%
	France (1870-71 and 1870-73)	
7.2%	4.1%	-7.6%
25%	7.5%	0.2%
	France (1871-72 and 1871-74)	
7.2%	1.5%	11.7%
25%	2.9%	8.1 %

Notes: ω is the French share of world GDP; μ captures the home bias in the consumption of traded goods; non-traded goods prices comprise a share γ=0.5 of the price index; the elasticity of substitution between traded and non-traded goods is θ=0.75; the elasticity of substitution between exports and imports is λ=1.5. Consumption is measured on a per capita basis. Appendix B gives the sources for the historical data.

Table 2: Calibration

Parameter	Value	Description
σ	1	Inverse of elasticity of substitution in consumption
β	0.94	Discount factor (annual real interest rate is $(1-\beta)/\beta$)
ν	1.0	Inverse of elasticity of labor supply
η	1	Weight on labor supply in period utility
θ	0.75	Elasticity of substitution: traded and non-traded goods
λ	1.5	Elasticity of substitution: import and export goods
γ	0.5	Share of non-traded goods in consumption
μ	6.5	Home bias in traded-goods consumption
α	0.36	Share of capital in export sector production
κ	0.36	Share of capital in non-traded sector production
δ	0.1	Annual rate of capital depreciation (in both sectors)
ϕ'/ϕ''	0.3	Elasticity of q with respect to the investment-capital ratio
χ	-0.01	Elasticity of real interest rate to net foreign assets
ω	0.165	Share of France in world GDP

Note: Parameter values are discussed in section 6.

Figure 1: French Current Account/GDP

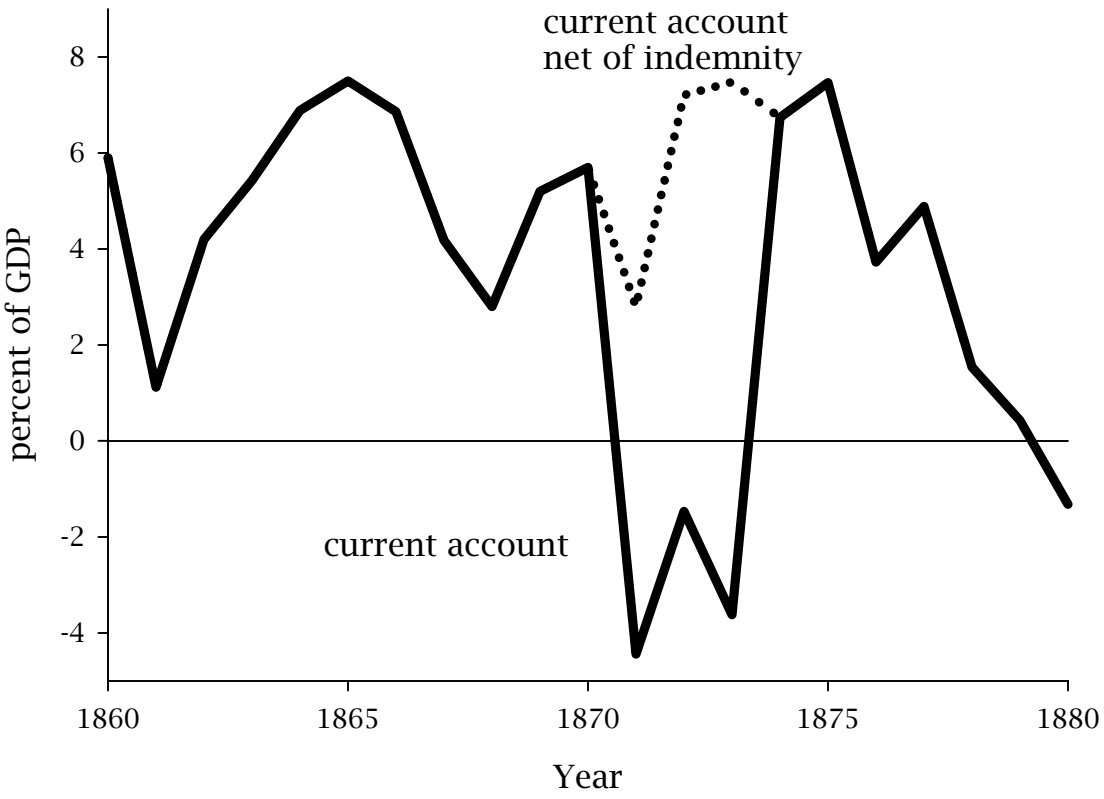

Figure 2: French Terms of Trade and Net Export Share

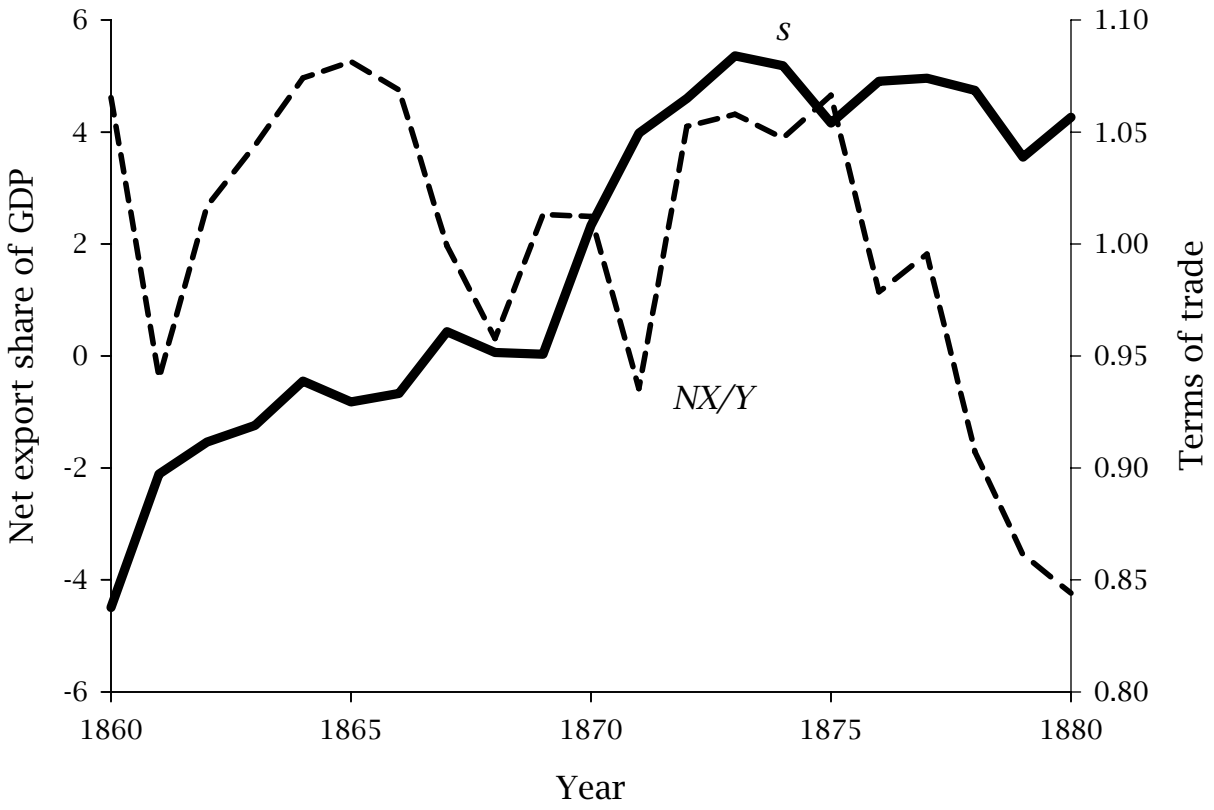

Figure 3: Responses to a Transfer

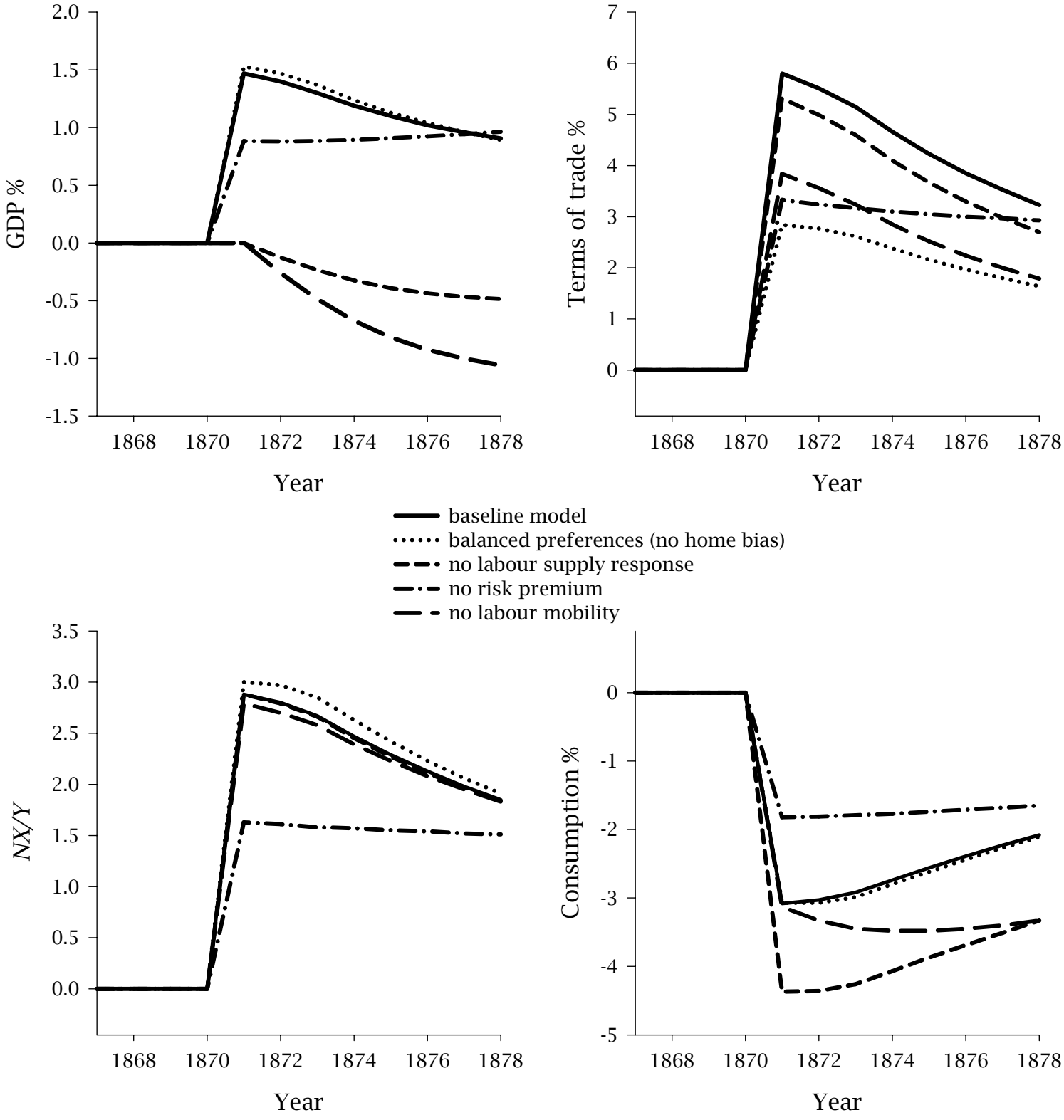

Figure 4: Transfer and Fiscal Effects and French History